POWER PLANT ENGINEERING

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For Soldiers in the Making

REFRIGERATING AND ICE MAKING, WATER AND HEATING PLANTS INSTALLED AT ROCKFORD CANTONMENT FOR THE HEALTH AND COMFORT OF 40,000 MEN IN TRAINING

IMMEDIATELY AFTER THE DECLARATION of war by our Congress against Germany, steps were taken by the War Department for the creation of an army, the ultimate size and fighting efficiency of which promises to be second to none in the world. Due, however, to the unprepared condition in which the United States then was, it was necessary to institute the selective draft and to provide ways and means by which the men thus chosen might be properly trained for the arduous task ahead of them. To provide this training in the shortest possible time, consistent with the high standard of our regular army and national guard units, 16 training camps each capable of caring for from 30,000 to 40,000 men were erected in various sections of the country in record-breaking time.

One of the largest of these camps is Camp Grant, located approximately 6 miles south of Rockford, Ill., outside of a large bend in the Rock River, and on a rich farm land plateau of 4000 acres, 35 ft. above the river. At the present time, this training camp has housing facilities for 40,000 men and contains somewhat more than 1700 buildings, each of the majority provided with electric light, steam heat, running water and sewage disposal systems.

Of the 22 miles of roadway within the reservation, 7.5 miles are of heavy concrete macadam, 18 ft. wide, 8 in. thick at the center and 6 in. at the sides, 3½ miles are of gravel and the remaining 11 miles are graded earth roads.

THE HEATING SYSTEMS

ONE OF THE MOST interesting features of Camp Grant from an engineering viewpoint is the steam generating plants and the distribution systems used to furnish heat to the various buildings. The cost of this equipment is said to have been about $3,000,000.

Except for a number of comparatively small isolated plants ranging in sizes such as will enable them to care for from 650 to 4500 sq. ft. of radiation and used only to serve some of the outlying structures, officers' quarters, etc., the greater part of this service is cared for by fifteen power houses placed about the reservation. In all but plants numbers 14 and 15, Erie City Iron Works boilers, each rated at 150 hp., have been installed, plants numbers 8, 9 and 10 having three units each, plants numbers 1, 2, 3, 6, 7, 11, 12 and 13 having four units each, while power houses numbers 4 and 5, which are under a single roof, contain eight boilers. The largest of these, however, that used in conjunction with the base hospital, shown in Fig. 5, and known as plants 14

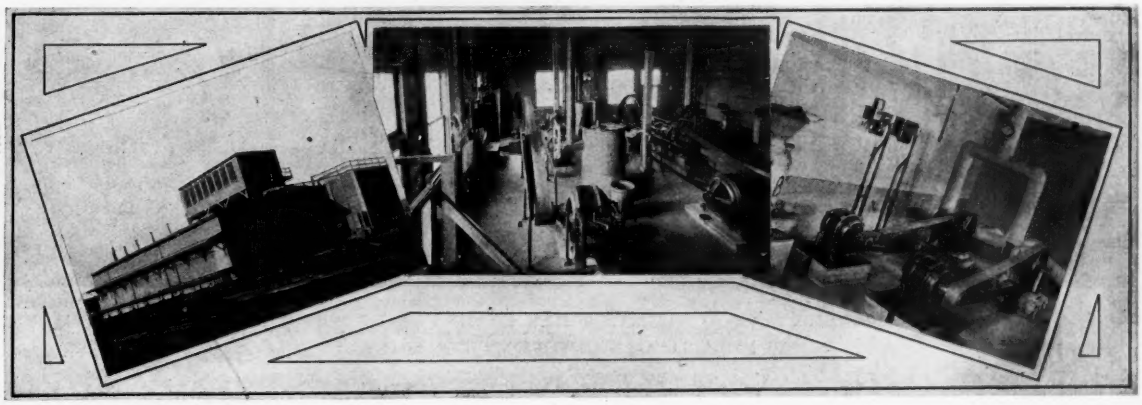


FIG. 1. EXTERIOR OF REFRIGERATING PLANT, SHOWING CONDENSER AND COOLING TOWER. FIG. 2. MOTOR DRIVEN BRINE CIRCULATING PUMPS. FIG. 3. INTERIOR OF COMPRESSOR ROOM

and 15, contains ten Kewanee boilers, also rated at 150 hp. each. These are placed in two rows back to back with six units in one row and four in the other, thus allowing ample ground space for the installation of two additional boilers which might at any time in the future be required.

In general, regardless of the number of boilers installed, a standardized design of plant structure and equipment has been employed. Essentially, as shown in Fig. 6, each boiler house consists of a wooden structure of such size as to allow sufficient room on all sides and overhead to gain ready access to the boilers for operation, cleaning and repairs. Directly in front of the firing doors and within easy reach of the fireman is the coal bin. This, having in each case a capacity of approximately 20 tons for each boiler installed, practically consists of an extension of the building on the firing aisle

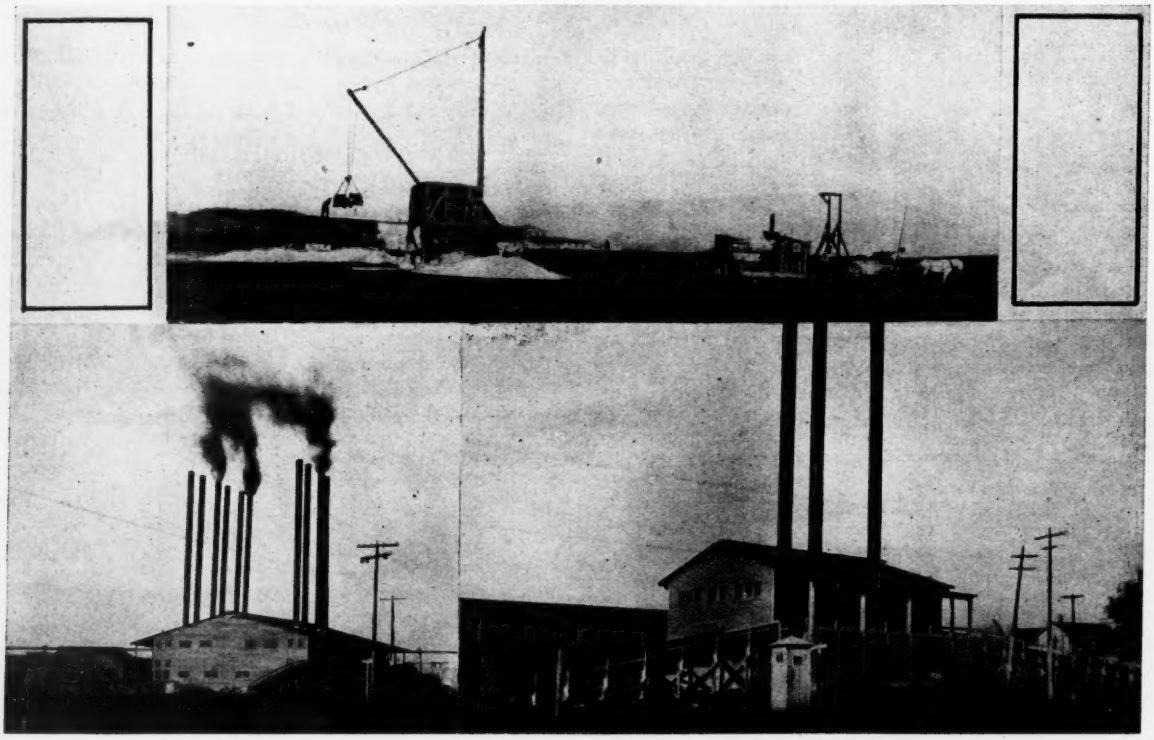


FIG. 4. COAL UNLOADING EQUIPMENT. FIG. 5. THE TEN-BOILER HEATING PLANT WHICH SERVES THE HOSPITAL UNIT. FIG. 6. A TYPICAL THREE-BOILER PLANT

side with a height such as to allow of delivery trucks being driven above the bins by means of inclined trackways provided for the purpose. The truck being of the dump bottom type, the coal can be dropped in front of the boilers eliminating much manual labor, otherwise required.

All firing is done by hand and each boiler is fitted with an individual 82-ft. steel stack which provides the necessary draft.

Water for feed purposes is taken directly from the lines of the camp water system, but as the pressure maintained in this has been found insufficient to force the water against the pressures ordinarily carried in the boilers, the installation of auxiliary feeding equipment has been found necessary. This consists of a number 12 Garfield injector and one 6 by 4 by 6-in. Worthington duplex steam pump for each four boilers, the pump being used only in case the injector becomes inoperative.

A blowoff main carried along the rear of the boilers and connecting with the various boilers by means of branches each of which carries a globe valve and a blow-off cock, discharges all water and sediment to the outside of the building.

Steam Distribution System

Of the 1700 or more buildings found at Camp Grant, 1692 are supplied with heat, the total number of square feet of radiation installed being about 970,000.

Steam which is generated at an average pressure of about 15 lb. gage (higher pressures being maintained in severely cold weather) is carried from the main headers through 8-in. overhead lines to the barracks and other buildings served, where, by means of pressure reducing valves its pressure is reduced to about 2 lb.

The distribution lines which are insulated with successive layers of tar paper, sheet asbestos, 1-in. felt and finally a covering of special prepared roofing are suspended 20 ft. above the ground by means of ring hangers attached to double cross arms mounted on poles as indicated in Figs. 7 and 8. Suspension is accomplished by angle irons spanning the two cross arms and through the center of which is drilled a hole to accommodate the ring bolt which is held in place by a washer and nut at the upper end. Where but one line is carried the form of bracing illustrated in Fig. 7 is employed. The branch lines serving the various barracks pass directly through the buildings, and at such points bends are provided to

compensate for expansion, although in most cases each line has at least one slip expansion joint, especially if the line is of considerable length.

No returns are used in the barracks heating system. Radiator outlets are connected to the building return line which terminates in a trap, the condensate being allowed to discharge to the atmosphere.

Coal Supply

Considerable coal is required, not only for the heating plants, but also for use in the camp bakery and the barracks kitchens. This is delivered in gondola cars and stored in the open on a large stretch of ground provided for the purpose near the outskirts of the camp; removal of the coal from the cars is done entirely by hand. That required for immediate use is, however, taken from the cars by one or two unloading equipments, shown in Fig. 4, and consisting of a clam-shell bucket

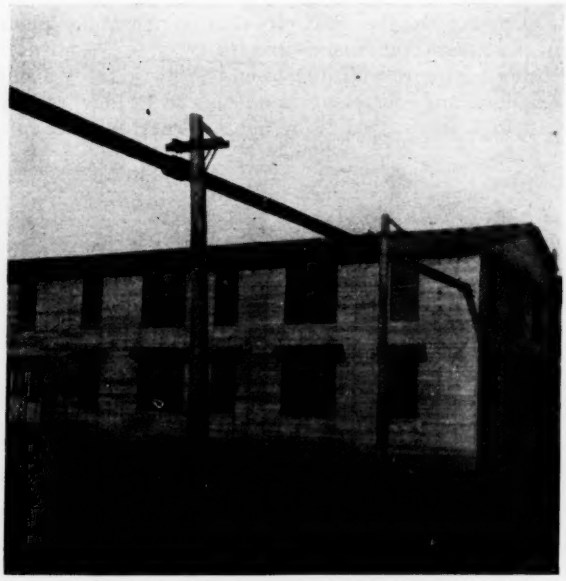


FIG. 7. METHOD OF SUPPORTING STEAM DISTRIBUTION LINES

carried by a boom and operated by means of a small donkey steam engine. As the coal is taken from the car, it is dumped into an elevated receiving hopper in the form of an inverted pyramid, having a capacity of about 9 or 10 tons. Wagons and trucks driving under this hopper take the required amounts through a chute provided for the purpose.

Large lumps are crushed by means of a crusher resembling a miniature pile driver shown at the right of Fig. 4.

Refrigeration and Ice Making

Located near the outskirts of the reservation is the refrigeration and ice-making plant, a frame structure having overall dimensions of approximately 100 by 60 ft. and a height of 22 ft. The building is divided into two sections, one of which houses the ammonia compressors and auxiliary apparatus, the freezing tanks and the ice storage rooms, while the other contains the beef storage, the butter and egg cooler, the general provision cooler, the shipping room and the office.

As may be seen by referring to Fig. 3, the refrigerating equipment consists of two 25-ton Vilter horizontal ammonia compressors of the double-acting type. Each of these is belt driven by a 50-hp., 2300-v., three-phase, 60-cycle, General Electric induction motor with wound rotor connected in series with a cast grid rheostat, thus allowing the speed to be varied to meet operating requirements. The motors are independently controlled by

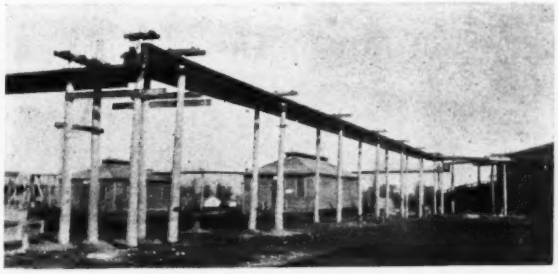


FIG. 8. HEAVY STEAM LINE CONSTRUCTION USED IN CONNECTION WITH HOSPITAL UNIT PLANT

type K-20 oil circuit breakers equipped with double series inverse time limit overload relays and no-voltage release relays, also of General Electric make.

Brine is employed for refrigerating purposes and the manufacture of ice. This, for the former service, is cooled in the 16 by 6 by 6-ft. deep tank shown at the right of Fig. 3, and is circulated through a system which, except for the main headers, is made up of 1¼-in. black-iron pipe assembled as coils and placed in the cooling lofts above the cold storage rooms. The ice melting capacity of these coils is from 10 to 15 tons each 24 hr.

Two 2-in. Viking brine pumps, each driven by a 3-hp. General Electric induction motor have been installed to circulate this brine.

In the beef storage room which has a capacity of about 410 quarters of beef, are approximately 3700 ft. of 1¼-in. brine pipe; in the butter and egg storage,

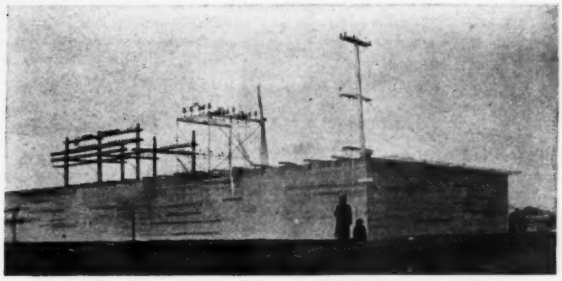


FIG. 9. ELECTRIC SUBSTATION, SHOWING INCOMING HIGH-TENSION LINES AT RIGHT AND 2300-V. DISTRIBUTION LINES AT LEFT

which has overall dimensions of 15 by 34 by 10 ft. high, are 1800 ft. of this same size of pipe, while in the provision cooler with its contents of 4700 cu. ft., are 2200 ft. of brine piping. Temperature in the beef and butter and egg storage rooms is kept at about 32 to 33 deg. F.; in the general provision room the degree of refrigeration maintained depends entirely upon the nature of the goods in storage.

Natural circulation of the air as it passes through continuous ducts occupying the entire length of each side of the storage room and going then to the cooling loft above, is depended upon to provide the necessary refrigerating effect. In the loft above the beef storage room are two 72-ft. racks each four pipes wide, one being six pipes high and the other seven pipes high; the racks in the butter and egg cooler are each 27 ft. long, five pipes wide, eight pipes high on one side and six pipes

FIG. 10. PUMPING STATION AND WATER RESERVOIR

high on the other; those in the general provision room are each 36 ft. long, five pipes wide and six pipes high.

Walls and ceilings are of wood with a four-layer lining of paper and a well tamped fill of wood shavings, thus insuring a high degree of heat insulation.

Ice-Making Equipment

An extension to the compressor room houses the ice-making equipment consisting in the main of freezing tanks having openings for three hundred and sixty 300-

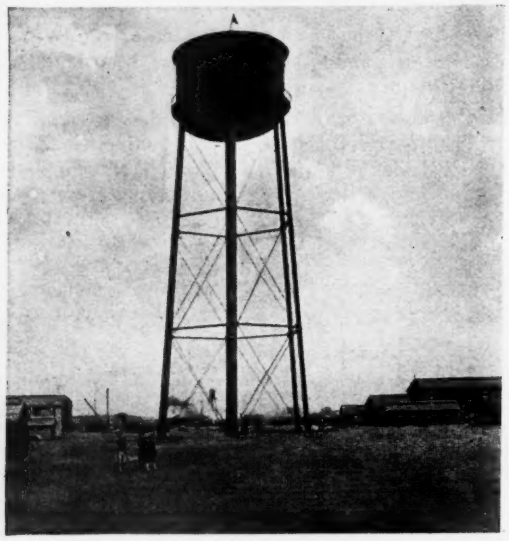


FIG. 11. WATER STORAGE TANK

lb.-cake ice cans with an ice-making capacity of from 25 to 35 tons of raw water ice per day. At the present time, however, but about six tons are being manufactured each 24 hr., and that at a rate of nearly 45 hr. per cake. When frozen, the cakes are removed by hand-operated traveling cranes (one being installed for each half of the freezing room) and are delivered to automatic dumping cradles which discharge the cakes through automatic ice chute doors into a storage room of about 60,000 lb. capacity. The temperature here is ordinarily maintained at about 28 deg. F.

Eleven sections, each eleven pipes high and made up of 1¼-in. stock, make up the brine cooling equipment contained in the freezing tank, and in order to maintain proper circulation of the brine, two agitators belted to a 5-hp., 220-v., 3-phase induction motor have been installed. In addition there is also a core sucker pump.

In order to reduce the consumption of water to a minimum, that which is employed for condenser cooling purposes is re-used indefinitely. After leaving the condenser it is passed through a cooling tower having overall dimensions of approximately 16 by 29 by 24 ft. high and a rated capacity of 150 gal. Circulation of this water is maintained by a 120-gal. per min. American Well Works centrifugal pump direct connected to a 5-hp. driving motor.

Condenser and Cooling Tower

Located on the roof of the refrigerating plant directly above the compressor room is the condenser housing having overall dimensions of 36 by 19 by about 12 ft. high and containing seven coils 20 ft. long, twenty pipes high and spaced 20 in. apart. These connect to a

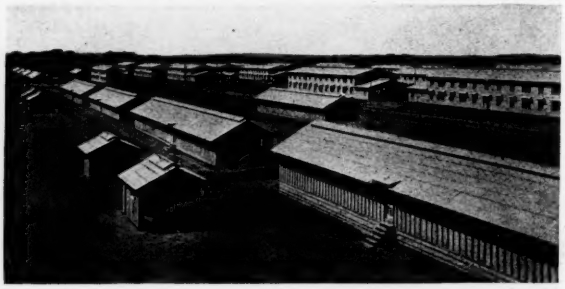


FIG. 12. GENERAL VIEW OF ONE SECTION OF CAMP GRANT

3½-in. discharge header carrying a 12-in. by 2-ft. 6-in. oil separator; a 12-ft. by 20-in. liquid receiver is also provided.

After passing over the condenser coils the water used for this purpose flows from the condenser pan by gravity through a 6-in. line terminating in a 4-in. distributor fitted with ten 3-in. branches to two water troughs at the top of the cooling tower. The water is collected in a receiving pan at the bottom of this tower and removed through a 3-in. line connecting with the suction of the circulating pump which returns it to the condenser above; from there the cycle is repeated.

Personnel

For the operation of this plant and for the distribution of the ice to the various barracks kitchens are required one chief engineer, three shift engineers, three assistant shift engineers, one clerk, three ice handlers and eleven laborers, all of whom are enlisted men.

During such periods of the year as 24-hr. operation is necessary, the shift engineers and their assistants are on duty 8 hr. each day, with the shifts changing every two weeks.

Water Supply

Unable to secure an adequate supply of water from the city of Rockford, not only for domestic service, but

also for the remount depot, the steam heating and the refrigerating plants, the need for an isolated system was at once recognized. Little trouble, however, attended obtaining an ample supply of a water containing but 16 grains hardness per gallon and practically free from bacteria, by drilling through a layer of clay approximately 30 ft. deep. As a consequence six wells, each 200 ft. deep, were sunk on a flat near the Rock River, where it flows by the camp.

into the distribution system to which is connected near the center of consumption a 250,000-gal. elevated tank with 150-ft. head.

Parallel 12-in. mains connect the pumping station to the storage tank and the distribution mains which consist of a series of interlocking loops so arranged that any section may be cut out without disturbing any other part of the system, are made up of 12, 10 and 8-in. sections. Approximately 30 miles of these service lines have been

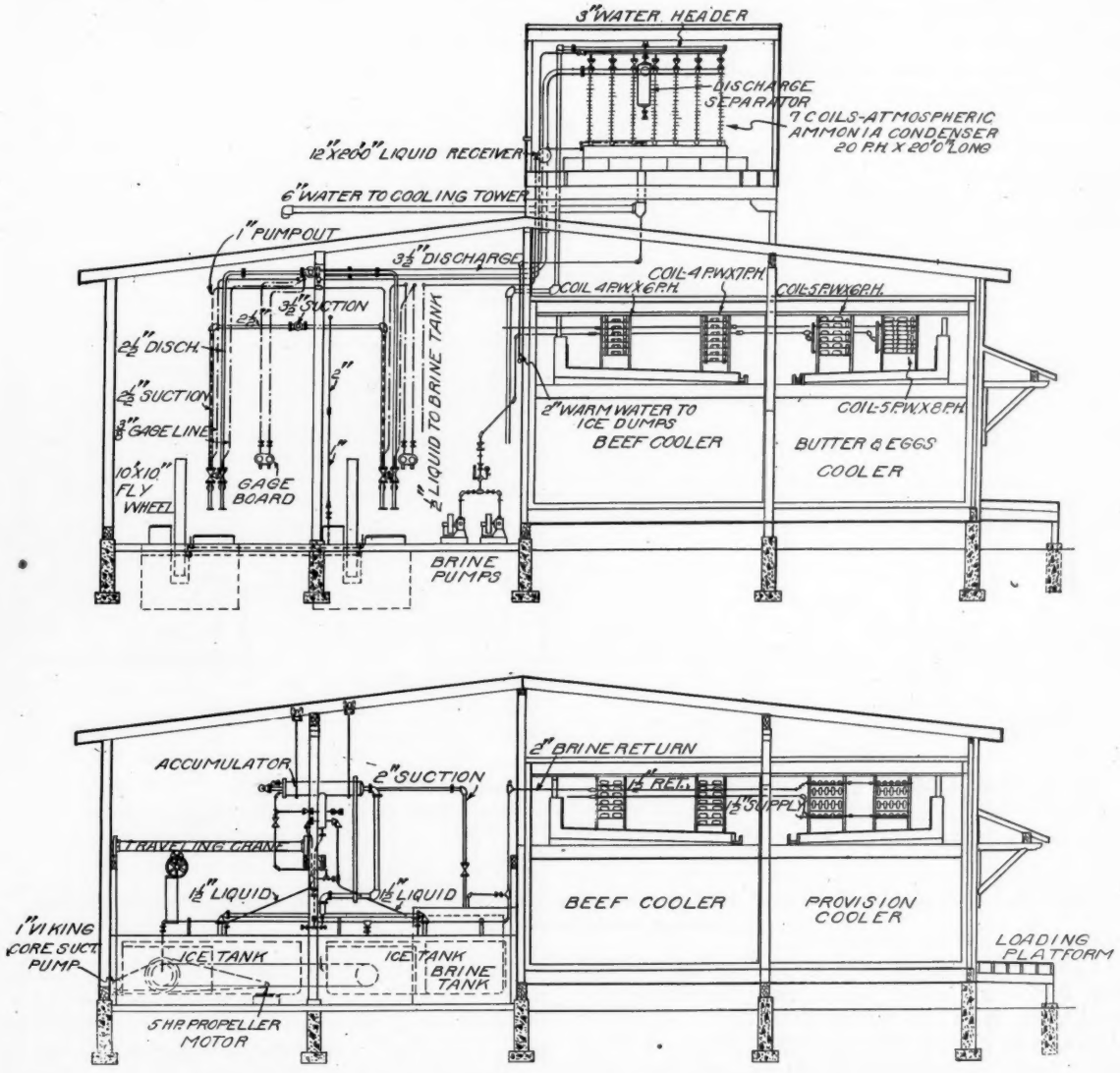


FIG. 13. CROSS SECTIONS THROUGH REFRIGERATING PLANT

From these wells which are interconnected, the water is removed by submerged air nozzles forming part of an air system operating in conjunction with three motor-driven air compressors, each having a rating of 500 cu. ft. of air per minute, and is discharged through a collector line into a surface concrete reservoir of 300,000 gal. capacity. The air compressors are housed in the building shown in Fig. 10, as are also four 1000-gal. per min. Alberger motor-driven centrifugal pumps which again pump the water from the storage reservoir directly

laid, all buried to a depth of about 5 ft. below the surface, which, together with the system of continuous circulation employed, practically insures the water against freezing.

While the maximum capacity of the water supply system is 5,000,000 gal. for each 24 hr., at the present time the demand is for but about 2,300,000 gal. per day. Ordinarily a pressure of about 60 lb. per sq. in. is maintained.

The Sewerage System

This, which is 23 miles in length and for the greater part laid comparatively near the surface in order to prevent cave-ins and facilitate repairs and alterations in the layout, empties into the Rock River directly opposite the reservation.

Electric Service

Current for electric light and power is supplied the cantonment by a 13,200-v. transmission line connecting with the generating station of the Rockford Electric Co. This furnishes energy to the sub-station picture in Fig. 9, wherein it is stepped down to 2300 v. for local distribution to the transformers which serve the various buildings and street lighting circuits. In each of the barracks are about sixteen 60-w. lamps and for street and general exterior lighting lamps are bracketed to the corners of buildings and in some instances to the poles carrying the electric lines.

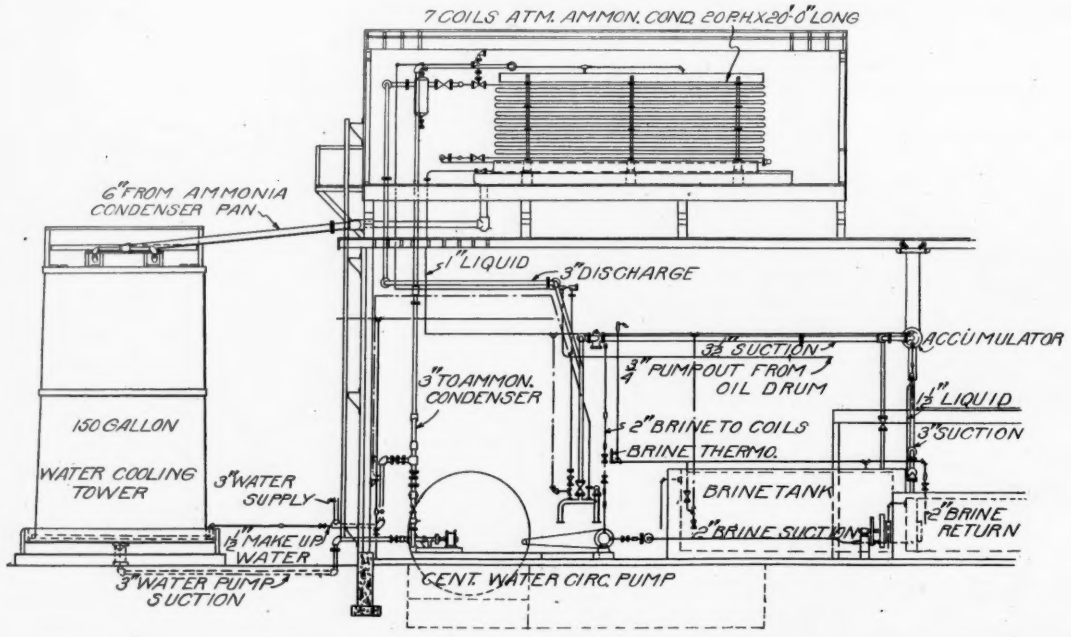


FIG. 14. LONGITUDINAL SECTION THROUGH PORTION OF REFRIGERATING PLANT, SHOWING MACHINE ROOM, CONDENSER HOUSE AND COOLING TOWER

One hundred and ten volts is used for lighting and 220 v. for power, except where heavy motors are employed, such as in the refrigerating plant. Here the motors operate directly from the 2300 v. lines. The total lighting load is approximately 600 kw. and the power load about 300 kw. although a total of nearly 700 kw. in electric motors has been installed.

Acknowledgment

The various branches of service referred to above are in direct charge of the Utilities Division of the Quartermaster's Corps, and it is due to information given and courtesies extended by Lieutenants Hobart, H. R. Behr and C. W. Older, heads of the departments of steam plants, refrigeration and ice-making, and water works respectively that the preparation of this article has been possible.

Blasting the Soot Out of a Stack

Sooty smokestacks are wasteful of fuel. A safe and economical way of cleaning them by the use of blasting power is suggested by the Du Pont magazine. For this purpose a "gun" is used, made of an old piece of pipe shafting about 4 in. in diameter and 14 to 16 in. long. A hole 1¾ in. in diameter and 10 in. long is bored in one end of this shafting, converting it into a small cannonlike arrangement, and a touchhole ½ in. in diameter is bored through the side about 9 in. from the end, connecting with the center bore and serving for the fuse. This gun is then mounted on a pedestal 6 in. in diameter to hold it upright.

The method of operation is as follows: Pour blasting powder into the mouth of the cannon to about 2 in. from the top. Tamp to the collar with dry clay. A short piece of fuse is inserted in the touchhole and in contact with the main powder charge. Open the flue door at the bottom of the stack, set the cannon on the bottom and in the center of the stack, light the fuse and close the flue door. The explosion shakes and loosens the soot adhering to the sides, causing it to fall to the bottom. It can then be removed through the flue opening.

A charge of 8 in. of FFF powder, 1¾ in. in diameter, is sufficient for a stack up to 100 ft. high and 4 ft. in diameter or over. The number of shots necessary to clean the stack thoroughly depends upon its condition. Ordinarily three or four shots will clean a stack, but if very dirty it may require more. The size of the charge and length of the cannon can be regulated to suit the height and diameter of the stack. There is no doubt about the efficiency of this "gun" for cleaning smokestacks.

The iron in a man's body would make a modern steel bullet large enough to kill him.—The Gas Engine.

Power Plant Instruments as an Investment—IV

USE OF STEAM FLOW METER TO INCREASE PLANT EFFICIENCY. BY M. A. SALLER

THE development of accurate, reliable and commercially usable meters for measuring the flow of steam is comparatively recent, and hence this class of apparatus is not so generally used at the present time as it will be later, when its benefits become more widely known and appreciated.

In any boiler plant making steam for consumption in various departments or industrial processes, the use of the steam flow meter is of great assistance in checking the steam consumption of the various points of use, and thereby enables an accurate and fair distribution of the cost. Where heating systems are in service, the measurement of the steam going to the heating system enables a proper charge to be made for this service. Figure 1 shows a chart record of a steam meter in one plant, which graphically indicates that the steam was turned into the heating system shortly after 5 a.m., that at 8 o'clock the power load came on, that steam was shut off for about 20 min. at noon, that the engine load gradually decreased in the afternoon until 4:40, when the engines were shut down, leaving only the heating load, which continued until midnight.

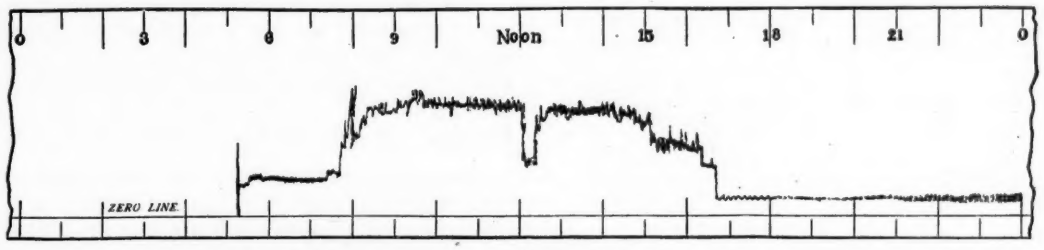


FIG. 1. CHART RECORD OF FLOW METER INDICATING THE DURATION AND EXTENT OF THE HEATING AND ENGINE LOADS. THE DISTANCE BETWEEN ZERO LINE AND STEAM LINE, MULTIPLIED BY A FACTOR GIVES THE QUANTITY OF STEAM IN POUNDS PER HOUR FLOWING AT ANY POINT

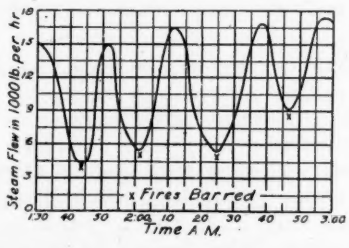


FIG. 2. PLOTTED FLOW METER READINGS SHOWING VARIATION IN BOILER OUTPUT

As affecting the power plant itself, however, the matter of the use of steam flow meters in connection with the betterment of boiler efficiency is of the greatest importance. The steam flow meter record giving the instantaneous rate of the quantity of steam being produced is of particular value in checking up boiler efficiency that otherwise might be incorrectly judged solely by the determination of CO_2 and draft conditions and the rate of steam output averaged over a considerable period of time. It is often possible for the firemen to aim for a high CO_2 reading at a sacrifice of capacity and fuel economy—the immediate and constant check afforded by the flow meter readings will soon bring to light such conditions.

In plants using only one or two boilers the steam flow meter can be used instead of the feed-water meter to show the amount of steam generated while at the same time showing how the boilers respond to adjustments of feed water, steam pressure, draft, and firing. In a small plant, however, either the feed-water meter or the steam meter can be dispensed with, the record from either serving all the purposes required.

Especially, however, in connection with large boiler plants containing a number of boilers connected to a common header does the steam flow meter prove to be a most excellent investment. In such cases the amount of feed water as usually recorded covers the consumption of the entire plant and from it the general efficiency of the plant as a whole is obtained. It will be found, however, that in any large battery of boilers even operating under similar general conditions some units will be operating at high efficiency while others will lag behind, though the general overall efficiency may be such as to cause this lagging back in one or two units to be unnoticed. Figure 2, plotted from flow meter readings on one boiler unit shows a variation in steam output of from 30 to 125 per cent, which led to an investigation as to the cause, which revealed the fact that the cams on the automatic stoker were so worn that the fire was not sufficiently open for proper combustion excepting just after the fire had been barred. Five minutes after barring, the steam delivery would fall from the maximum to the minimum point. As it was

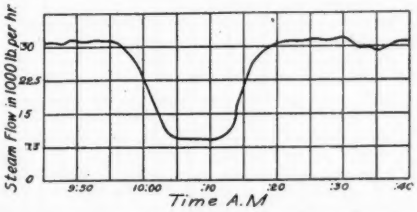


FIG. 3. PLOTTED FLOW METER READINGS SHOWING DECIDED DROPPING OFF IN CAPACITY DUE TO FIRE DYING OUT AT THE REAR END OF THE CHAIN GRATE STOKER

customary to bar the fires once every 15 min. before the meter records were secured, it meant that the boiler had been idle about ⅔ of the time. Replacement of the defective cam of course eliminated the trouble entirely.

A steam flow meter placed on the outlet of each boiler will show just how that particular boiler is behaving, and will immediately show it up when its efficiency and capacity begins to fall behind, due to scale, soot, improper firing, etc. Figure 3 shows another set of flow meter readings, indicating a decided dropping off

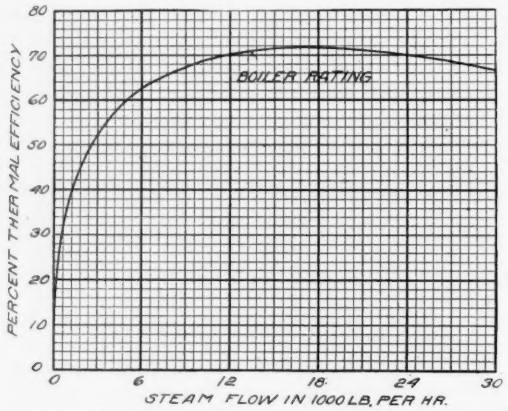


FIG. 4. REPRESENTATIVE CURVE ILLUSTRATING DECREASE IN BOILER EFFICIENCY RESULTING FROM REDUCTION IN OUTPUT

in steam production from one boiler unit. The investigation which followed this tell-tale disclosed the fact that the fire was dying out at the back end of a chain grate stoker for a distance of about 2 ft. The output dropping from approximately 30,000 to 9000 lb. per hr. was quickly detected, however, and immediate steps taken to bring the output up to normal. Without the meter tell-tale this inefficient condition might have lasted a considerable length of time.

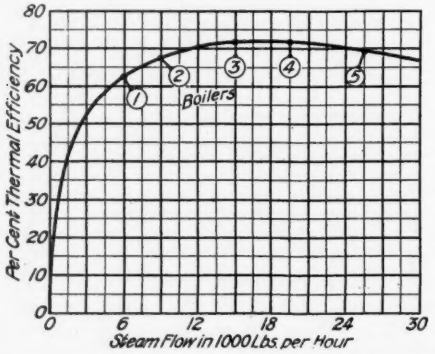


FIG. 5. SHOWING LOAD ON FIVE BOILER UNITS UNEQUALLY DIVIDED, RESULTING IN AN OVERALL EFFICIENCY OF 69 PER CENT

The indications of a steam flow meter in a large plant also permit the advantageous adjustment of the load on the various boilers in service so that each unit can be made to bear a proper share of the work. It will also show when the maximum desirable point of overload has been reached, and when it is necessary to cut in other units, or vice versa, when the load falls so low that it can be carried more efficiently on a smaller number of boilers. More and more is it becoming apparent that it pays to drive boilers at high rating in order to secure the best efficiency, and this indication by the flow meter of when the load is falling or rising from the most efficient level is of great importance in arranging for the timely and efficient management of boiler capacity. Figure 4 shows a representative curve illustrating the decrease in boiler efficiency resulting from a reduction in output. Figure 5 shows the load on five boilers, unequally distributed, resulting in a mean efficiency of 69 per cent, while Fig. 6 shows the result when the load on the five boilers is carried equally because the fires, draft, etc., are regulated in accordance with the indications of the flow meter connected to each battery. In the latter case the efficiency curve gives the total battery efficiency as 72 per cent, resulting in a saving of 4¼ per cent in the cost of making steam.

The manner or rate at which the feed water is supplied to the boiler also has a marked effect on the overall efficiency. The steam flow meter acts as a very definite guide for following in making feed-water adjustments and regulations. As the quantity of feed water is increased the momentary capacity of the boiler is

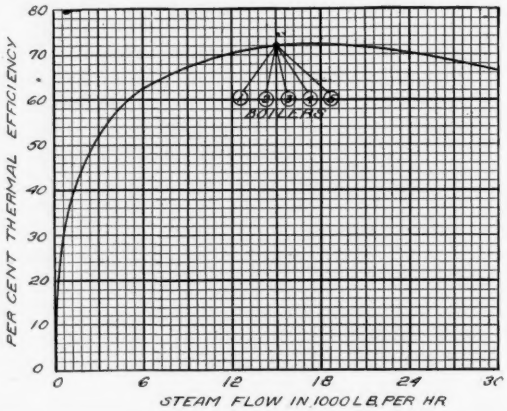


FIG. 6. SHOWING LOAD ON THE FIVE UNITS EQUALLY DIVIDED AS A RESULT OF THE GUIDANCE OF THE FLOW METER READINGS RESULTING IN AN OVERALL EFFICIENCY OF 72 PER CENT

decreased while the cold feed is being heated, and conversely by cutting out the feed supply the boiler can momentarily be made to deliver more steam since it is relieved of the feed-water heating demands. Tests on a 650-hp. boiler unit show that feeding water intermittently, and with constant firing and load conditions, an average evaporation of 11.8 lb. of water per pound of coal was obtained. When feeding the boilers at a steady rate in accordance with the load demands, and with the same load and fire conditions as before, an evaporation of 12 lb. per lb. of coal was obtained, or a gain in efficiency of 1.7 per cent—a small percentage in itself but which will amount to a very considerable sum when applied against the year's coal bill.

The field of the flow meter is very decidedly in the large plants made up of many units operating at very high efficiency, and where a constant check over furnace and load conditions is necessary in order to prevent wastes, however slight. Also in isolated plants furnishing steam for heating or other purposes to an outside customer, the steam meter is almost indispensable.

Oil Burning Plants

METHOD OF ESTIMATING AMOUNT OF FUEL REQUIRED. BY G. S. BLANKENHORN

WITH the rapid introduction of oil as fuel in steam power plants comes the problem of calculating the overall economies which may be realized by the use of this fuel.

The writer, desiring to show how this may be done, will work out a specific case with conservative assumptions based on current Pacific Coast practice. The plant chosen is one having a 5000-kw. steam turbine using 14.8 lb. of steam per kilowatt-hour, with a throttle pressure of 190 lb. gage, 125 deg. F. superheat and a vacuum at the exhaust nozzle of 28.5 in. of mercury when referred to a 30-in. barometer. Calculation is based on a load factor of 100 per cent.

Auxiliary equipment consists, let us say, of a steam driven exciter set (turbine or engine) of 50 kw. capacity and using 60 lb. of steam per kilowatt-hour; a surface condenser, having a slow speed steam driven dry air pump, a high-speed steam driven centrifugal circulating pump and a turbine-driven condensate pump requiring a total of 150 hp. and using 45 lb. of steam per brake horsepower-hour. In addition, there are oil pumps using 300 lb. of steam per hour and a boiler feed pump of 60 hp. using 42 lb. of steam per horsepower-hour.

Steam is generated by three water-tube boilers of 823 hp., equipped with superheaters and working under a pressure of 190 lb. gage and 125 deg. F. superheat. Feed-water temperature is assumed to be 180 deg. F. The boilers are to be equipped with internally mixed oil burners using steam as the atomizing medium.

Summing up the entire steam used per hour by the main unit and its auxiliaries, we have:

Turbine,	5000×14.8	= 74,000
Exciter set,	50×60	= 3,000
Condenser,	150×45	= 6,750
Boiler feed pumps,	60×42	= 2,520
Oil pumps,		= 300
Total,		86,570

Factor of evaporation is equal to

$$\frac{H - (h - 32)}{r}$$

where H = total heat corresponding to steam at 190 lb. gage and 125 deg. F. superheat; h = total heat of feed water above 32 deg. F., and r is the latent heat of evaporation of steam at 212 deg. F.

Substituting the values of these factors as found in steam tables, we have factor of evaporation equal to

$$\frac{1271 - (180 - 32)}{970.4} = 1.158$$

At normal rating and under the above conditions, the boiler would generate $\frac{823 \times 3 \times 34.5}{1.158}$, or 73,500 lb.

Factor 34.5 in the above equation is the number of pounds of steam per hour to a boiler horsepower when the water is evaporated from and at a temperature of 212 deg. F. By dividing by the factor of evaporation (as found), we obtain the actual amount of water evaporated under the actual existing conditions.

As in the best practice of today boilers are operated considerably above their rating (50 to 75 per cent in many plants), these units will be found of ample size.

Now making the following assumptions: Amount of steam for oil burners, 4 per cent of total generated; loss due to condensation, 5 per cent; boiler efficiency, 77 per cent; loss in oil due to water, silt, etc., 1 per cent; and calorific value of oil, 18,500 B.t.u. per pound.

Total steam generated per hour will have to be 86,570 times 1.09, or 94,400 lb., the figure 1.09 caring for the above losses.

Useful number of British thermal units per pound of fuel is equal to the product of the number of thermal units per pound of fuel times the per cent boiler efficiency or 18,500 times 0.77, or 14,240.

Pounds of water evaporated per pound of fuel from and at 212 deg. F. = Useful number of British thermal units in fuel, divided by latent heat of vaporization of steam at 212 deg. F., or 14,240 divided by 970.4, or 14.7.

Actual evaporation per pound of fuel is equal to evaporation from and at 212 deg. F., divided by factor of evaporation, or 14.7 divided by 1.158, or 12.7.

There are 336 lb. of oil to a barrel, and if we allow a loss of one per cent, the available number of pounds of oil per barrel is equal to 336 minus 3.36, or 332.64.

Water evaporated per barrel of oil, pounds, is 332.64 times 12.7, or 4230, and the number of barrels of oil used per hour is equal to the quotient of the total steam generated per hour divided by the number of pounds of water evaporated per barrel of oil, or in this case, 94,400 divided by 4230, or 22.3.

The number of kilowatt-hours to be realized from each barrel may be obtained by dividing the generator output by the number of barrels used per hour, or 5000 divided by 22.3, which we find is equal to 224.

For a basis of comparison of oil burning power plant economies the number of kilowatt-hours per barrel of oil is always used, therefore the 224 is the figure we are interested in, in this case.

In conjunction with the above, let us figure the temperature of boiler feed water using as a basis water entering the heater at 70 deg. F., the exhaust from the auxiliaries, at 16 lb. absolute pressure, and the amount of water to be heated the same as in the above case, namely 94,400 lb. per hr.

Available steam at 16 lb. absolute pressure for heating:

Exciter	3000
Condenser	6750
Boiler feed	2520
Oil pumps	300
Total per hour	12,570

Total available heat in steam, B.t.u. per hour, is equal to

$12,570 \times H$, or
$12,570 \times 1152 = 14,500,000$.

H is the total heat in one pound of steam at 16 lb. absolute pressure.

Water to be heated, pounds per hour, is 94,400.

B.t.u. in water is equal to $94,400 \times (70 - 32)$, or 3,590,000, where $70 =$ temperature of water entering heater.

Total B.t.u. in mixture is equal to 14,500,000 plus 3,590,000, or 18,090,000.

Temperature of water leaving heater is $\frac{18,090,000}{94,400 + 12,570} + 32 = 201$ deg. F.

We find then that our assumption of 180 deg. F. for boiler feed water temperature was very conservative.

Smokeless Combustion of Coal*

SMOKE PRODUCING CONSTITUENTS OF COALS; RELATION OF CARBON MONOXIDE TO SMOKE; SUCCESSFUL FURNACE DESIGN. BY ROYCE L. BEERS†

INCOMPLETE combustion of the volatile products of coal results in a visible smoke emission from the chimney. This visible smoke consists of very small particles of solid carbon in the form of soot and hydrocarbon particles, or "tar vapors." When seen through a strong microscope, the small pieces of soot seem to be clusters of still smaller particles of carbon, which are, in fact, only about two one-millionth parts of an inch in diameter, and it is on account of this small size that the carbon in this form is so easily carried in even the slowest gas stream. Besides the visible smoke solids, there are emitted from the chimney invisible solids which consist of very small particles of ash that are carried in suspension. These invisible solids may be of larger amounts than the visible solids, especially in furnaces where a higher rate of combustion is smokelessly maintained; however, the invisible particles, although not desirable, do not create such a nuisance as the visible

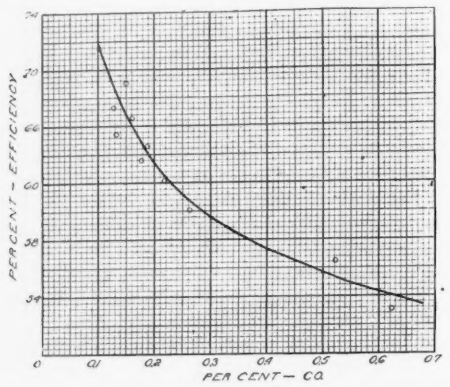


FIG. 1. VARIATION IN EFFICIENCY WITH DIFFERENT PERCENTAGES OF CARBON MONOXIDE

solids, or smoke, and they will not be considered in this paper.

Smoke in itself represents a very small loss of heat from the coal. The weight of the carbon particles in a very dense smoke may be about 1 per cent of the weight of the coal fired; but smoke represents incomplete combustion, and the conditions which prevent the complete combustion of these carbon particles would also prevent the complete combustion of some of the invisible gases of high heating values. The loss by not burning these gases may be very large. The curve, Fig. 1, was plotted from results of a series of tests conducted by the U. S. Geological Survey and shows how the efficiency varied with the carbon monoxide. An efficiency of 72 per cent being obtained with 0.1 per cent CO and dropping to 54 per cent with an increase to 0.6 per cent CO.

The relation of CO in the flue gas to smoke is shown by Fig. 2, smoke increasing rapidly with an increase

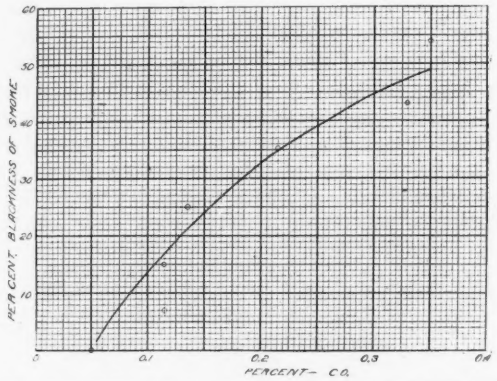


FIG. 2. RELATION OF SMOKE DENSITY TO PERCENTAGE OF CARBON MONOXIDE IN FLUE GASES

of CO. The preceding curve of Fig. 1 shows that efficiency drops with an increase of CO.

To design properly a furnace for smokeless combustion of a particular type of coal, requires a knowledge of the volatile gases of the coal, and the conditions under which it is to be burned. Smoke is not caused from the

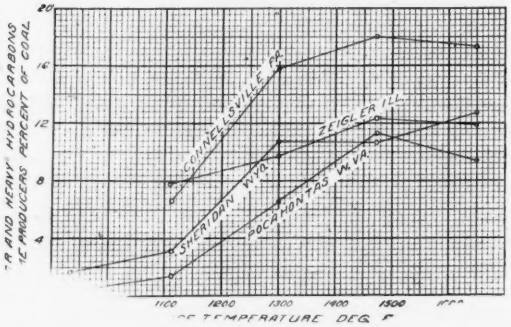


FIG. 3. RELATION OF FURNACE TEMPERATURE TO SMOKE PRODUCERS IN VARIOUS COALS

incomplete burning of fixed carbon of the coal, but from the incomplete combustion of the volatile gases. The volatile matter of different coals varies in its composition. The composition of these gases usually consists of tar, water, carbon monoxide, hydrogen, nitrogen, me-

*Abstract of paper read before the Smoke Prevention Association.
†Of the U. S. Radiator Corporation.

thane, and a complexity of hydro-carbons. The heavier hydrocarbons, such as benzine, naphthalene, ethylene, methane, acetylene and others, are the most difficult to burn smokelessly, because they are comparatively slow burning, and require a plentiful supply of air and a thorough mixing with it. High volatile coals in general are more difficult to burn without loss than low volatile coals; but the amount of volatile gas in a coal is not so much an index of its smoke producing tendency, as is the richness of the volatile matter in hydrocarbons and the relative ease with which the volatile matter may be set free.

The curves of Fig. 3 show the variation of tar and heavy hydrocarbons or smoke producers with furnace temperatures, for representative coals of West Virginia, Pennsylvania, Illinois and Wyoming. It will be noticed that the coals of Connellsville, Fayette Co., Pa., have more smoke producers than the coals of Zeigler, Franklin Co., Ill., although each has approximately the same percentages, about 38 per cent of volatile matter. Also, the coals of Sheridan, Wyo., have higher percentages of volatile matter than either of the above coals, but have less smoke producers.

Some coals with less than 30 per cent of volatile matter give off more smoke than other coals containing 40 per cent. Coals of the Pittsburgh district give off heavy

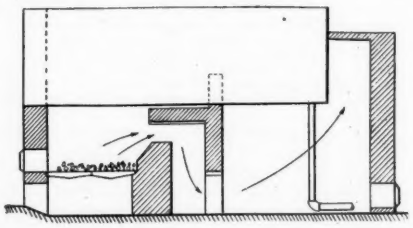


FIG. 4. FURNACE WITH IGNITION AND DEFLECTION ARCHES

hydrocarbons and gases in abundance and tend to produce excessive smoke. The sub-bituminous and lignitic coals of the West, though containing a higher percentage of volatile matter, produce gases and vapors that contain a large proportion of inert matter such as water and carbon dioxide. These latter types of coal do not tend to cause excessive smoke unless burned at high rates of combustion. There are also intermediate types of coal such as those of Illinois and Iowa. Competitive tests on two coals are recalled in which the volatile matter represented respectively 20 and 25 per cent, but the lower volatile coal gave off more smoke than the higher volatile, due to the nature of the volatile matter, and to the action of the coal on the grates which required more attention.

Now, to prevent the formation of smoke there are three fundamental conditions that are necessary: First, there should be a small excess air supply over the fuel bed to obtain complete combustion of the gases; second, the gases and air must be thoroughly mixed; and third, a sufficient high ignition temperature should be maintained until the gases are completely burned. The emission of smoke at the larger plants, which are mostly mechanically stoked, seems to be well under control. High efficiency is striven for, and as a result there is very little smoke emission. At the smaller plants, however, conditions are different. The more expensive equipment is not installed, the higher grade of skilled help is not had, and the smoke problem seems to be mostly in dealing with these smaller plants.

Analyses of gas taken at the surface of the fuel bed of hand-fired furnaces have shown that there is a deficiency of air with percentages of carbon monoxide as high as 10 per cent in some cases, besides the usual volatile products. With thin fuel beds, the formation of carbon monoxide is not so noticeable as it is in deep fuel beds. The formation of carbon monoxide may be best explained by considering the fuel bed divided into three layers. Next to the grate is a layer of ashes through which is passed free air. Above this is what is termed the oxidizing zone. Here the oxygen of the air unites with the carbon of the coal, and carbon dioxide is formed which represents complete combustion. Above this zone, however, is what is termed the reducing zone. Here there are very high temperatures, and it seems that this high heat causes a further reaction, in that the already formed carbon dioxide is broken up, and this uniting with the carbon of the coal forms the high heating value gas carbon monoxide. Experiments have shown that with a compact uniform fuel bed, it is impossible to get an excess of air passing through the live coals; that the higher the blast of air passing through the bed of burning coals, the faster the latter burns.

It is known that visible smoke is not gas, because gases are not visible. Besides the tiny pieces of carbon, at least part of the smoke is composed of minute globules of tar which have been boiled off in a vapor condition somewhat like steam from water. Now, the volatile matter rising from the fuel bed consists of gas and vapors. The gases consist of free hydrogen, carbon monoxide and several of the lighter hydrocarbons. The vapors are the heavy hydrocarbons and carbon-hydrogen compounds which may exist as minute tar globules, although surrounded by gases at a high furnace temperature. The simple gases such as hydrogen and carbon monoxide burn very readily with oxygen, the combination consisting of a single reaction; however, the combustion of the gaseous hydrocarbons may be a series of two or several reactions, the first reaction of each series partly burning the gases and partly reducing them to simpler combustible, either gaseous, or solid. These reactions take place close to the fuel bed, and quickly if the temperature is maintained and the mixture is good. This is one reason why cold heating surfaces as in extremely low settings, tend to produce smoke.

The tar vapors, being in the liquid globular form, require, even with a high temperature and a uniform mixture, a much longer time for their complete combustion, because oxygen can act only on the surface of each minute globule. As each globule burns, an insulating film of the products of combustion is formed around it and prevents rapid contact with more oxygen.

Best results with the up-draft hand-fired tubular boiler are usually obtained by admitting air, preferably preheated through the furnace front, just at the surface of the fuel bed. This gives the air a chance to sweep across the surface of the fuel bed and to unite with the tars and hydrocarbons while they are in their primary condition, and to facilitate the necessary reactions for complete combustion.

It is also, in some installations and with certain fuels, desirable to admit air at the rear of the furnace. This throws the combustible gases between two layers of air, that of the front admission on top and that of the bridge wall on the bottom. The effectiveness, however, of admitting air through the bridge wall is dependent more largely on the facilities for mixing the gases in the combustion chamber than of admitting air at the front of the furnace, and this point should be kept in view when the relative value of the two methods is considered in the design of the furnace.

Besides its being essential that a slight excess of air be provided over the fuel bed, it is just as essential that it is not admitted in too great an excess. Too large a volume of air admitted will lower the boiler efficiency by absorbing heat from the fire and will tend to cool the unburned gases, causing their precipitation and smoke. Probably too much excess air is the major cause of low efficiency in a great many plants. This air is not admitted to prevent smoke, but enters through leaks in the setting, and through holes in the fuel bed. The air through the grate and through a level fuel bed is used in combustion and is necessary for burning the coal; a reasonable amount of air admitted through the openings provided over the fuel bed helps to burn the volatile combustion of the coal, but most of the air that enters through the cracks in the brick setting and holes in the fire is not used in combustion, but merely absorbs and carries away heat.

It has been shown that it is necessary to have a slight excess of air over the fuel bed for the combustion of the volatile matter, but in order to obtain this complete combustion, it is necessary to mix the air and the gas. In observing a sluggish bituminous coal fire, it will be noticed that there are long, dull, red flames which pass off in layers and finally terminate in smoke. If these luminous tars and hydrocarbons had been thrown in contact with oxygen while at a high temperature, there would have been complete combustion and no smoke. In a large majority of smoky furnaces, although there may be long gas travel before the gases reach the cooling surface, there are no projections or obstructions to disturb the smooth flow of the combustible gases. Consequently, since there is not a thorough mixture of the luminous combustible solids and gases, there is a long flame from lack of oxygen and when the temperature of the luminous particles is lowered, due to lack of oxygen and cooling, precipitation occurs in the form of soot and smoke.

The slow combustion of the tar can be made faster by increasing the rate of diffusion of the film of products of combustion enveloping the globules. This can be done by creating a relative velocity between the gas stream and the globules; that is, by making one move faster than the other by changing slightly the direction of the main stream of gas. The resulting friction gives a process of scrubbing, which removes from the globules the insulation of the gaseous products of combustion.

Figure 4 shows a form of mixing chamber that has given good smoke results with return tubular boilers. It consists of an ignition arch over the bridge wall and a deflection arch back of the bridge wall. This deflection arch causes mixing and allows the gases to be completely burned before passing into the fire tubes.

Inserting in the path of the gases a long narrow slot of small cross section causes the gas to contract and expand, induces such relative velocity and thoroughly mixes the air with the combustible gases. Figure 5 illustrates how this slot mixing chamber can be applied to a return tubular boiler. The flames are spread out by this slot and the action is somewhat similar to the ordinary gas lighting jet. A stream of air flowing with the gases is flattened and will be thrown in contact with much more of the combustible gases than if it remained in a round stream.

Trouble was experienced with a city smoke inspector by burning soft coal in an internally fired marine boiler to heat an apartment building. Dense smoke was always emitted from the stack for some time after firing. To remedy the trouble, two vertical brick walls were built 15 in. back of the bridge wall, forming a vertical narrow slot. Since this installation was made, there has been no trouble from smoke and the boiler has given excellent results.

There has been a prevailing idea that steam jets were a cure for all smoke troubles. It cannot be denied that they assisted in the mixing of air and the gases and

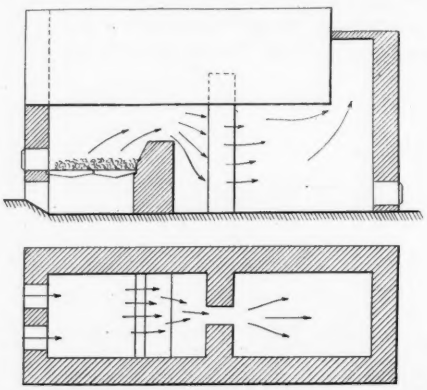


FIG. 5. APPLICATION OF MIXING ARCH TO RETURN TUBULAR BOILER

giving smokeless results, but their value has been overestimated. If the owner would stop and compute the pounds of steam that were then being used, and the corresponding dollars that were going up the stack, greater efforts would be made to find a more economical substitute.

Temperature, the third requirement for complete combustion, is essential, but it has been generally misunderstood. As has been stated, the luminous part of flame, which is the solid combustible particle raised to a high temperature, does not indicate combustion, but that the particles are ready to burn if brought in contact with oxygen. If they are cooled as they would be by striking a cold surface, their temperature will be lowered below the ignition point, and there will not be complete combustion; however, if they had been thoroughly mixed with oxygen while at their high temperature before being cooled, complete combustion would have occurred.

It is also true that extremely high temperatures seem to cause smoke in hand-fired furnaces. This, however, is not caused by the high temperature, but by the condition that produced the high temperature. When the amount of air admitted is low and approaches the theo-

retical amount necessary to burn the combustible, the temperature is raised; but as there is a deficiency of air, all of the combustible is not mixed with the oxygen of the air and smoke is formed. With powdered coal furnaces, high temperatures are obtained without forming smoke. This is because a minimum amount of air is used and the air and powdered coal are intimately mixed.

With a number of boiler installations, the heating surface is altogether too near the fuel bed. The combustible gases are divided up into small streams by the fire or water tubes. The gases are chilled below their ignition temperature and smoke is produced. It is absolutely essential that sufficient space be allowed for the complete combustion even with sufficient air and good mixing. The rate of combustion must be high enough to maintain a high temperature over the fuel bed and the gases should flow in large streams until the combustion is completed. By keeping the gases in one large stream, and with proper mixing, the temperature will be maintained until combustion is complete, even in an internally fired boiler with comparatively cold surrounding surfaces. Experiments have shown that there is a loss of efficiency by having an arch over the furnace of a return tubular boiler such as shown in Fig. 6. The heating surface exposed to the radiant heat of the fuel

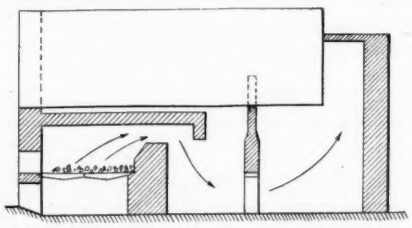


FIG. 6. FURNACE DESIGN WHICH PREVENTS RADIANT HEAT FROM REACHING BOILER SHELL

bed is most active and efficient. An arch like this shuts off the radiant heat and thus lowers the boiler efficiency.

The rate of combustion also has an effect upon the length of the flame. With very low rates the flame will be short, usually due to insufficient mixing, low temperature and incomplete combustion. With high rates the gas travel will be much faster and the flame will be longer. A furnace that has mixing devices and passages designed for burning smokelessly 20 lb. of coal per square foot of grate per hour, will give off smoke when forced to 40 lb. per hr; the combustion space being insufficient and the flame longer, the unburned gases strike the cooling surface before combustion is completed. With extremely low rates of combustion in the same furnace, the volume of gas being small, it will not be thoroughly mixed or maintained at a high temperature, and will pass off partly unconsumed.

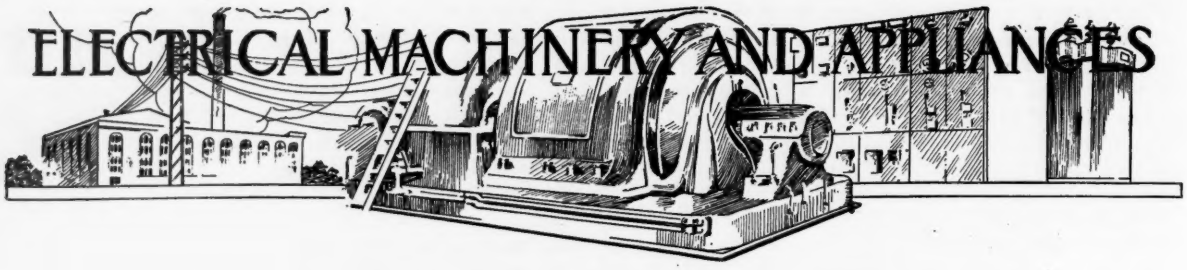
Too much emphasis cannot be given to the importance of draft. If there is poor draft, it is practically impossible to obtain smokeless combustion. Frequent pokings of the fuel bed are necessary to maintain the load and this causes a too free liberation of the volatile gases. With a poor draft, sufficient air will not be drawn in over the fuel bed. The gases pass off in a sluggish stream and with a lack of sufficient velocity there will not be good mixing.

With a deep, clean fuel bed more economical results and better combustion are obtained than with a thin bed in a fire-box boiler. This is true especially at the lower rates of combustion with proper mixing and a combustion chamber. That can be accounted for by the fact that with a deep fuel bed there is a greater heat transfer from the live coals to the water. There is less chance for air holes and consequently there is a more thorough mixture of the air and the gases as they rise from the fuel bed. Also, there being a higher percentage of carbon monoxide formed in the deep fuel bed, this gas when mixing with the supplementary air keeps the stream of gases at a high temperature, and facilitates the combustion of the smoky constituents of the volatile gas. Of course, in a brick set furnace a deep bed of fuel burning at a high rate of combustion would give excessive clinker trouble unless manipulated with great care.

A big fault with the majority of the so-called smokeless furnaces is, that they require too much attention to secure smokeless results. Steam jets require constant attention. They should be automatically regulated, given constant attention, and closed when the fire conditions warrant. If not, there is excessive waste of steam. Likewise in a number of hand-fired furnaces with supplementary air openings, the mixing chamber is not efficient. A large excess of air is required immediately after firing, and if the openings are not reduced when the greater bulk of volatile matter has been burned, there is a loss of heat due to heating up this excessive air. Firemen are not inclined to keep automatic regulation in good working order, nor are they likely to keep opening and closing the hand-operated supplementary air openings. The aim should be to have the supplementary air openings set in a fixed position, have frequent firing intervals, and have a more efficient mixing device that will so thoroughly mix the gases and air, that the minimum amount of air can be used. Most horizontal return tubular boiler settings are too low. They should be raised, and this will provide more room for combustion and ample space for a mixing chamber.

Even with a well designed furnace, some intelligence and care in firing must be expected. With an ideal furnace and a mechanical stoker, smoke can be made if the fires are improperly handled, especially at the time of cleaning. Likewise in hand-fired furnaces where there is usually not such a high grade of firemen in service, more smoke will be made and more coaching is necessary. Each fuel and each installation is a separate problem. The fundamentals for complete combustion are the same in each case, but may require a little different service. Best results in general will be obtained by providing equipment that is simple in construction and that does not require excessive effort or too close attention to operate.

SHEET LEAD may be used for making a small pattern in a hurry when a casting is wanted for experimental purposes. The lead can be easily cut and formed by hand to any required shape and soldered at the joints to hold the pieces together. By the judicious use of iron rods or pipe to reinforce and hold the shape, long slender patterns can be made in this manner and pressed sheet tin pans and other hollow metalware may be used also to build up a fairly complex form of considerable size.—MACHINERY.



Lightning Protection---III

TYPES OF APPARATUS EMPLOYED AND THEIR PRINCIPLE OF OPERATION. BY TERRELL CROFT

THE electrolytic lightning protector provides, probably, the most effective insurance against lightning damage now known. Protectors of this type can be furnished for alternating-current and direct-current circuits of any commercial voltage. Their disadvantages are that they are relatively expensive and that they require a certain amount of attention; however, these disadvantages are of minor consequence when expensive equipment is to be protected. Only the alternating-current protectors will be described here.

The principle of the electrolytic protector may be understood from a consideration of Figs. 20 and 21. The protector consists of a stack (Fig. 20) of cone-shaped, aluminum plates or trays spaced about 0.3 in. apart. A solution of electrolyte is poured into the spaces between the plates. The completed stack is mounted in an iron tank which is then filled with oil which not only prevents the evaporation of the electrolyte, but also prevents a rapid rise in temperature when the protector is discharging. The upper plate of the stack is connected to a horn gap (Fig. 22). The lower plate is usually grounded on the tank which is also (on a grounded neutral system) connected to ground.

The chemical action of the electrolyte usually is such that it forms on the surfaces of the aluminum plates a film of hydroxide of aluminum. At voltages below about 350 (Fig. 21) this film has an exceedingly high resistance; however, at voltages in excess of 350 the resistance of the film is very small. Thus, an electrolytic cell, arranged as suggested, forms an electrical safety valve which operates at a pressure of approximately 350 v.

However, at voltages below 350 some current would flow through the protector if it were left connected to a "live" line. Therefore, it is necessary to connect in series with it a horn gap, as shown in Fig. 22. The number of aluminum plates which is necessary to connect it in series is determined by the normal voltage of the line to be protected. There should be one cell, approximately, for each 350 v. of normal line pressure. Figure 23 shows the construction of an electrolytic protector for 135,000 v. Figure 24 shows a complete installation.

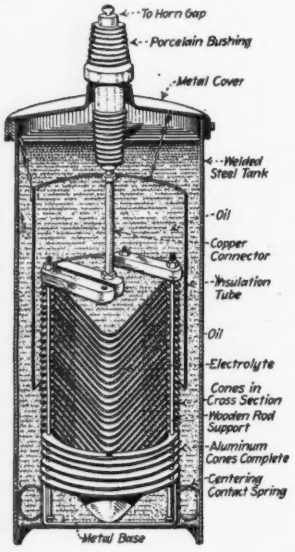


FIG. 20. SECTIONAL VIEW OF GENERAL ELECTRIC PROTECTOR

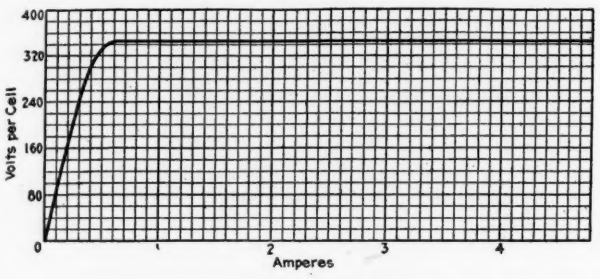


FIG. 21. GRAPH SHOWING HOW ELECTROLYTIC PROTECTOR PERMITS CURRENT TO FLOW READILY AT PRESSURES ABOVE ABOUT 330 V. PER CELL

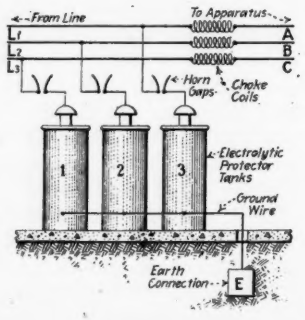


FIG. 22. DIAGRAM FOR A GROUNDED-NEUTRAL, THREE-PHASE ELECTROLYTIC PROTECTOR

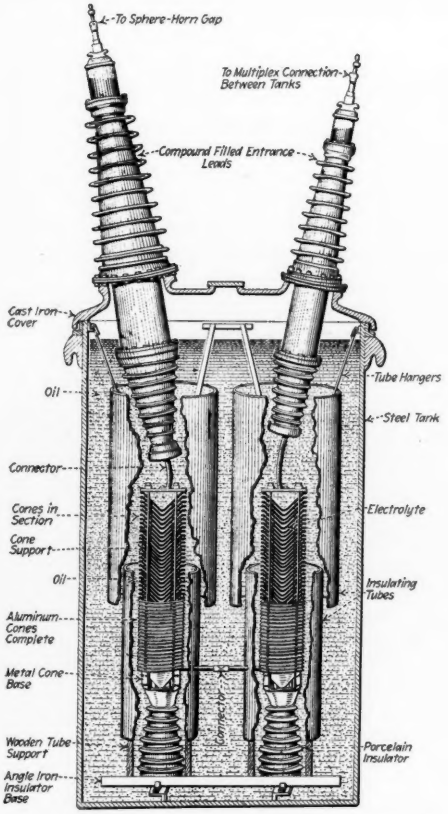


FIG. 23. SECTION THROUGH A GENERAL ELECTRIC 115,000 TO 135,000-V. ELECTROLYTIC TANK

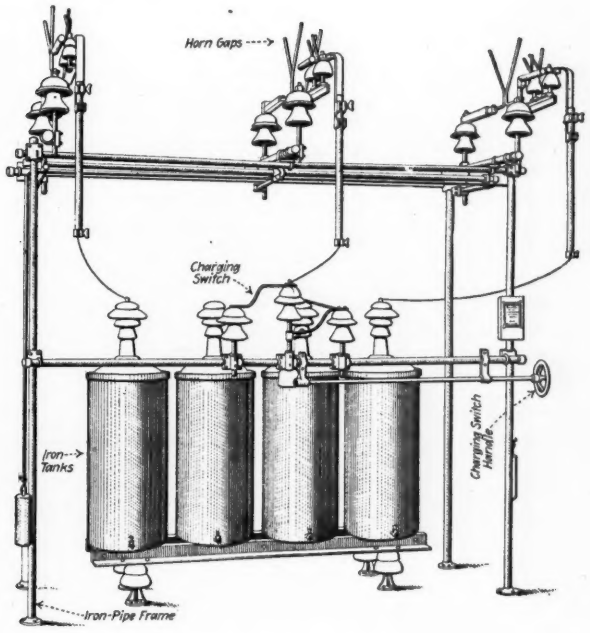
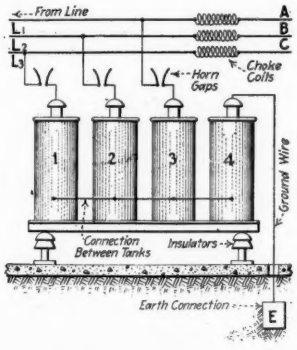


FIG. 24. WESTINGHOUSE ELECTROLYTIC PROTECTOR FOR A THREE-PHASE, UNGROUNDED-NEUTRAL, 22,000-V. CIRCUIT



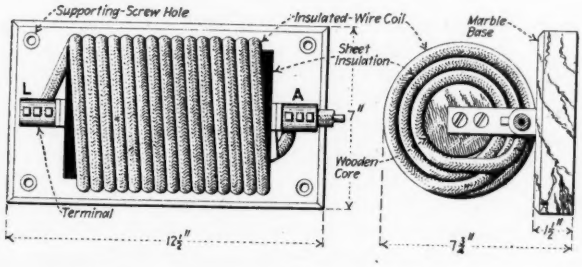


FIG. 25. DIAGRAM FOR AN UNGROUNDED NEUTRAL THREE-PHASE ELECTROLYTIC PROTECTOR

FIG. 26. GENERAL ELECTRIC CHOKE COIL FOR PRESSURE OF 6600-V. AND LOWER

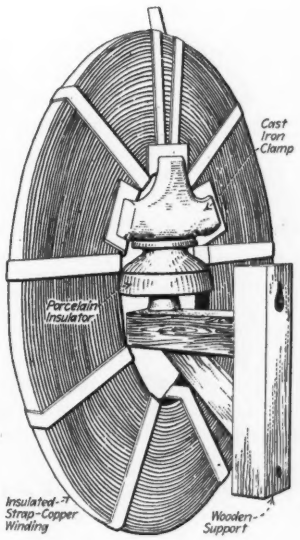


FIG. 27. WESTINGHOUSE "PAN CAKE" CHOKE COIL FOR PRESSURES OF FROM 2200 TO 25,000 V.

For charging an electrolytic protector the horn gaps are closed together by moving a suitably arranged lever. One side of the horn gap is hinged to provide for this.

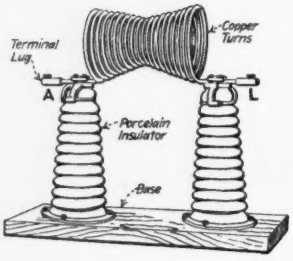
The arrangement of electrolytic protectors on grounded and ungrounded neutral three-phase systems is shown respectively in Figs. 22 and 25. Where the neutral is grounded, a voltage greater than the normal voltage between phase wires (L_1, L_2 and L_3) can never be impressed across any one of the three cells (1, 2 and 3) if they are arranged as shown in Fig. 22. However, if the neutral is ungrounded and an accidental ground occurs some place on the line, a voltage equal to almost twice normal voltage (1.73 by normal voltage) would be impressed across one of the protector tanks if only three were used (Fig. 22). Therefore, where the neutral is ungrounded, a fourth cell or tank (4) is placed in the ground lead, as diagrammed in Fig. 25, to insure that a voltage greater than normal will never be impressed across any one of the four cells. E is the ground connection.

In selecting choke coils it is necessary to exercise judgment. In a general way, the protective ability of a choke coil increases as the square of the mean diameter of the coil. With choke coils of equal length and equal mean diameter* the protective ability varies as the square of the number of turns. From the standpoint of lightning protection a large choke coil is desirable. However, the larger the coil the greater its impedance and resistance. If a coil is too large the voltage drop and energy loss in it will be excessive. Hence in selecting a coil, it is desirable to consider these features and choose one of a size which practice has shown to provide sufficient protection without excessive energy loss or voltage drop.

A choke coil for low-voltage circuits is shown in Fig. 26. It comprises merely a coil of insulated wire of sufficient cross-sectional area to carry the current of the circuit into which it is to be connected. This coil is wound on an insulating core which is mounted on an insulating base. Suitable terminals are provided. The core is not necessary except to insure mechanical rigidity. Home-made choke coils can be readily constructed by forming a helix of wire.

Air insulated choke coils for higher voltages are constructed as suggested in Figs. 27, 28 and 29. The type shown in Fig. 27 offers very effective protection, but is expensive because of the large amount of copper involved in its construction. Hence, coils of the general design of Figs. 28 and 29 (A is the apparatus terminal and L the line terminal) are used more frequently, particularly on very high-voltage lines for which the construction of Fig. 27 would not be suitable.

Oil-insulated choke coils are sometimes used on high-voltage alternating-current lines and comprise merely (Fig. 30) a coil immersed in a suitably-insulated and designed steel tank which is filled with oil. The oil insulates the coil against side flashes and dissipates the heat developed in it so that a conductor of small cross-sectional area can be used for the coil.



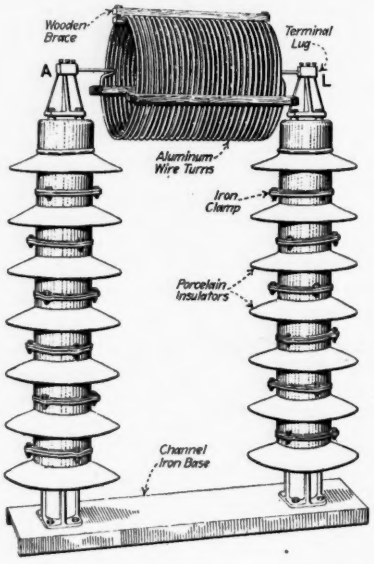


FIG. 28. GENERAL ELECTRIC "HOUR GLASS" CHOKE COIL
FIG. 29. AIR INSULATED CHOKE COIL FOR PRESSURES UP TO 150,000 V.

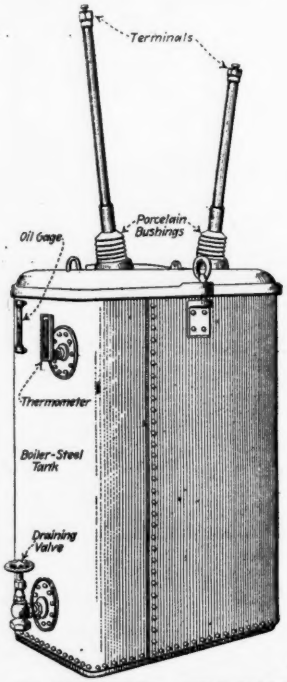


FIG. 30. WESTINGHOUSE OIL-INSULATED, SELF-COOLING CHOKE COIL FOR PRESSURE OF FROM 25,000 TO 70,000 V.

*Westinghouse Electric & Mfg. Co.

THE TOTAL production of bituminous coal, including coal coked, according to estimates of the United States Geological Survey, was at the rate of 1,855,537 net tons per day in the first eight days of December, as compared with 1,887,534 tons, the daily average for the week of Nov. 17. This indicates that production fell but little below the high level of November.

Locating an Invisible Error

POCKET COMPASS AND STORAGE BATTERY CURRENT SOLVES PUZZLING PROBLEM. BY MAURICE M. CLEMENT

AN interesting incident occurred while I was working in the West. A certain western power plant, situated in a small town, being purchased by a larger out-of-town concern, was thus put out of commission. Lines were being run in by the out-of-town plant, which carried a different voltage, thus creating a problem in regard to motors which were installed under old conditions. They either had to be replaced entirely by a new set of motors, or reconnected in such a way as to meet present conditions.

As the reconnecting was decided upon, a large force of motor repair experts were sent out to do the work. I, being one of these repair men, came across the following in the course of my work. A motor which I had just reconnected according to a connection diagram drawn by an engineer in the concern, I found to run far below specification speed. It was a 3-phase, 4-pole, series, star connected motor, speed 1200 r.p.m. When tested for speed it fluctuated between 300 and 400 revolutions.

All connections were gone over and all checked up with diagram; according to diagram the connections

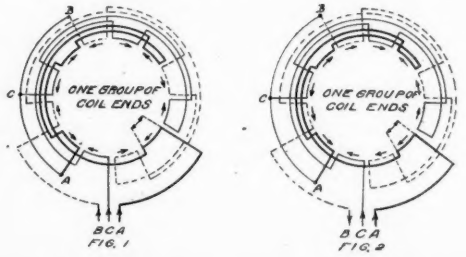


FIG. 1. DIRECTION OF CURRENTS IN COILS OF MOTOR WHEN USING DIRECT CURRENT FOR CHECKING WINDING
FIG. 2. INSTANTANEOUS CURRENT DIRECTIONS IN A.C. MOTOR

were correct, according to speed tests they were wrong. I will now go into the method I employed to find the mistake. It was novel and interesting. First, the machine was taken down and star connection was opened. Each phase was traced out and found to be correct. The star ends were then hooked together with a small wire and the leads connected to a storage battery; leads to positive side and star to negative side, causing the current to flow toward the star in all three phases and giving (as shown in Fig. 1, the arrows indicating direction of flow) a clockwise and counter-clockwise sequence.

We know, of course, that in a proper winding, assuming that the current is flowing toward the star in two phases and from it in the third, the arrows will fall in successive flights of three in the one direction and three in the opposite direction. This is illustrated in Fig. 2. The method used in Fig. 1 is simply a check to insure proper phase relations.

Now, to finish my test: A small pocket compass was placed close to number one group and the needle indicated a north pole. Numbers two and three also indicated north poles. Numbers four, five and six reversed the compass needle, indicating south poles. Numbers seven, eight and nine, north, and ten, eleven and twelve, south. According to Fig. 1, four of the poles, namely two, five, eight and eleven, were functioning in the wrong direction. It will also be noticed that the four poles thus affected compose the entire B phase; therefore, the B phase was working backward; in other words, the wrong end of the B phase was used for a star connection.

The connection diagram was examined carefully and the error of the B phase was located. It was then an easy matter to connect B star with A and C leads and B lead with A and C stars. Compass test was once more applied, this time proving Fig. 1. Motor was then assembled and, needless to say, came up to required speed.

Coal Waste in Idle Streams

FIGURES are dry, even those pertaining to water power. But the waste of fuel that cannot be replaced, because we are not using power of streams that is running to waste and can be seized only as it runs, is best shown by a few facts in figures.

Good authority gives 49,000,000 as the horsepower of the stationary power plants in the United States, and fuel experts claim that these plants use some 30 per cent of all coal mined in the country.

Meantime, as recently stated by secretary Lane, 35,000,000 hp. of undeveloped waterpower is wasted, and only 6,000,000 hp. is being utilized. If we used this wasted power, it would save 21.5 per cent of our yearly fuel bill. That means about 139,000,000 tons, or, say, $500,000,000—$5 apiece for every person in the country each year. Even more important, we should be saving that 139,000,000 tons of coal to be used in the future, thus prolonging to the race the advantage of a coal supply, which once exhausted cannot be replaced.

From another viewpoint, this wasted water power is equivalent to the daily labor of 1,800,000,000 men, more than 30 times our adult population, and 900 times the number we are proposing to use in the army for carrying on the war. This energy made available would solve all problems of lack of labor. But in addition, the work of mining, transporting and firing the coal saved would be abolished, releasing the labor of 380,000 men, while only 40,000 men would be required to operate the hydraulic plants, a net saving of 340,000 men available for other work. Besides, there would be set free nearly 200,000 cars, sadly needed for other transportation, and some 5000 locomotives.

All this because we have fussed and puttered over making the most of an opportunity that is daily wasted and daily renewed.

In the last Congress, bills passed the House and the Senate providing conditions for water power development, but the bills did not agree. Hence a deadlock; more delay; more coal burned while the energy of thousands of streams runs wasted to the oceans.

Nitrates we must have for ammunition manufacture and for crop raising. Chilean nitrates are almost impossible to obtain, owing to lack of shipping and the formation of a Chilean trust under government sanction. The atmosphere is a vast storehouse of nitrogen, but great

hydraulic plants developing power cheaply are needed to tap this store. Again we delay, while our stock of nitrates shrinks, and $16,000,000 appropriated for a government nitrate plant lies idle in the treasury.

The Shields bill is now before the Senate providing reasonable terms of water power development on the basis of 50-yr. leases. Money for the development cannot be had without some stability of investment conditions, but public rights beyond that time can be and are protected by the bill.

By allowing the developing of its power resources, Utah is saving 1,000,000 tons of coal a year. The question lies, shall the country have a law that will permit similar development in other states? Shall the expenditure of the $10,000,000,000 needed to develop our water powers be encouraged? Or, shall we go on quibbling for details of control that prohibit such expenditure on a basis of expectation of reasonable return on the investment? Control can be secured without confiscatory conditions. And we need that power that is going to waste. Now is the time to start development—on a reasonable basis—and legislation should be passed which will encourage it.

Overhauling an Atmospheric Ammonia Condenser

THE TROUBLE ENCOUNTERED IN OVERHAULING A LARGE SINGLE PIPE ATMOSPHERIC AMMONIA CONDENSER ON ACCOUNT OF THE COILS BEING MADE UP OF PIPE WHICH WAS GALVANIZED ON THE INSIDE AS WELL AS ON THE OUTSIDE. BY A. G. SOLOMON

THE season being cool enough to begin the overhauling, one coil of the ammonia condenser was to be pumped out, overhauled and put in service again before the next coil could be spared.

Each coil was made up of four stands 30 pipes high and 20 ft. long. The four stands were connected together, and to the main discharge line, by means of a 3-in. header or manifold. At the bottom, the four stands connected into a 2-in. manifold, which in turn connected into the main liquid line, through a 1-in. line. (Figures 1 and 2.)

This construction may have some points in its favor, but the disadvantages are many. Of course, there is a

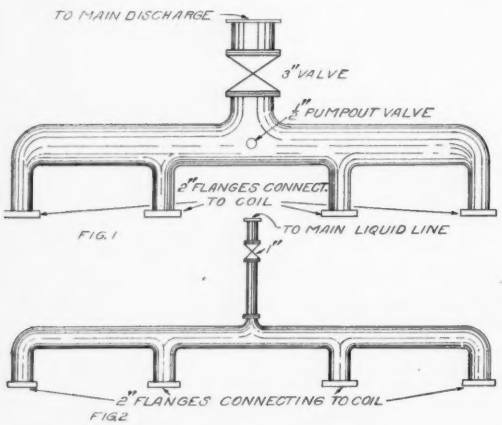


FIG. 1. INLET MANIFOLD

FIG. 2. OUTLET MANIFOLD

big saving in valves, as each coil requires only one liquid, one gas and one pump-out valve. With each stand as a separate coil, four times as many valves would be required; but the saving in valves was the only good point I ever discovered.

The gas or inlet valve was 3-in., and the liquid or outlet valve was 1-in. This 1-in. outlet never seemed big enough to allow a free and steady flow of the liquid from four stands.

I say this, so that if some refrigerating engineer who has a condenser built in this way, and has trouble with the liquid ammonia, can study out the conditions as they exist and perhaps change the condenser and obtain better results.

Four stands, as big as those mentioned, and made up to empty the liquid through a 1-in. outlet, will not work well, as one of the stands will, at times, handle more gas than the others, and the effect is the same as gas binding in three stands. When construction of this kind has to be handled, the water flowing over the stands must be watched closely, so that each stand gets the same amount as the others.

The valves on this entire condenser held extra tight and the first coil was pumped out clean.

A steam and air line had been extended, so that several coils could be blown out from the one connection. The arrangement of the lines is shown in Fig. 3.

A steam hose about 12 ft. long was used to convey the air and steam to the coils. A nipple was secured in each end of the hose, and on one of these was the half of a box union, and on the other was a 2-in. male flange, which mated with the female flange on the inlet of the stand. (Fig. 4.)

After the first coil was pumped out, the manifolds at inlet and outlet were taken down, and the four stands were ready for the internal cleaning with steam and air. Looking into the coils, they had the same appearance as any other condenser coils, except that the oil looked dirty, gray and heavy. Steam was then turned into the first stand, and it took about 10 min. before condensate began to come out at the outlet. Of course, it takes considerable time for steam to travel through 600 ft. of 2-in. pipe, when the weather is cool.

The oil and water mixed had a grayish color and came out in spurts. I waited for the condensate to come out clear, as it did in about a half hour. In a few minutes the water almost ceased to come and yet steam blew out.

The steam valve was then shut and the air valve opened after draining out the moisture by means of the ½-in. drain provided.

As there was no change of connections to make, the air went in at 90 lb. pressure, while the coil was still hot. Moisture came out of the bottom of the coil for a few minutes and then the air was so dry that it was

almost invisible. The air was left blowing for several minutes.

Then the bolts, connecting the hose to the inlet of the stand, were taken out, and the hose connected to the next stand. This arrangement takes very little time, as only two bolts are needed.

The inlet of the stand just blown was clean as new pipe, but when the outlet was examined, it had a queer grayish dust in it—not very much, but it could be seen and would show on the fingers when rubbed. This looked unusual, but was not given more than slight attention at the time. The four stands of this coil were blown out, and all looked the same as the first, both before and after blowing.

This condenser had been in service several years, and the bolts and gaskets in the divided return bends were all to be renewed. One end of the coil was made up entirely with screwed return bends, but the other end had seven divided bends, for convenience in disconnecting when repairs were to be made.

The bolts were taken out of all the flanges on the four stands, and the divided return bends wedged apart by means of an oak wedge used between the pipe and a piece of square wood which just fitted easily between the two pipes. This wedge held the flanges apart far enough to permit removing old and inserting the new gasket. The wedge was then knocked out, the bolts put in and tightened just enough to hold the flanges together. Every bolt on the whole job was well coated with graphite and oil. After the gaskets and bolts were in all the flanges of the four stands, a man went over every bolt and pulled them all up tight. The tightening was followed up again after the coil had been completed, tested and in service about two days. With this care leaks were almost unknown.

Whenever new divided return bends were put on, a practice was made to have the female flange on the bottom. This makes it easy to insert the gasket and there is no danger of a gasket dropping out.

While the coil was being overhauled, the scale was not neglected. This was removed while bolts and gaskets were being put in.

When this first coil was completed and put back in service, the next was taken and so on until the job was done.

New pipe was needed quite often to replace those that had sprung leaks and been clamped. Or leaks would be found where bends had been sweated on and calking had failed to stop the leakage. In the latter cases the joint would be taken apart, and if nothing was wrong with the threads on the pipe, or in the fitting, the joint would be made up again. This whole condenser was considered as a good sweat or soldered job. In taking off return bends, the only soldered part about a joint was the tin, which filled the recess in the fitting. The threads of neither pipe nor fitting showed any sign of tinning.

The manner of taking apart a leaking joint would depend on conditions, and the part of the coil where the leak occurred. If two or three joints had to be taken apart to get to the leaking one, it was found easier and cheaper to saw the return bend in two, and take off the two halves. Then a divided bend was made up on the pipes.

To remove one of the screwed (not divided) return bends, the section in which it was located had to be slipped so as to extend about a foot beyond the other sections. This was done by loosening the cast-iron stands which hold the coils upright and wedging them apart. Then, having opened up the divided return bend above and below the section to be moved, the slipping process was simply a case of using a bar and some strength. Then the bend to be removed was sawed in two. A blow torch was then used to melt the tin out of the recess and heat the bend. Holding back on the pipe with a wrench or a pair of small chain tongs, another wrench was used to unscrew the bend.

The threads on the two pipe ends were then cleaned by means of a solid pipe die, turned with a wide jawed open ended wrench. No sweat work was done, all joints being made up tight, with graphite and oil used as a lubricant on the threads. If the threads are good on the pipe and in the fitting, a graphite and oil joint will hold as well as any. And if threads are defective and a sweat joint is made, leakage will show in time. Calking a soldered joint is all right for a temporary job, but it must be made up right at the first opportunity. Several of those small leaks scattered throughout a plant amount to a great deal more than a person would think.

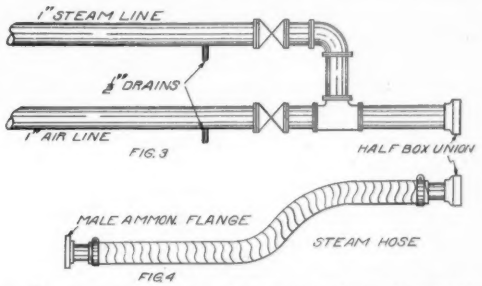


FIG. 3. STEAM AND AIR LINES TO HOSE CONNECTION
FIG. 4. STEAM HOSE SHOWING FITTINGS

In putting in a new pipe, the return bend was often sawed and a new divided bend, as well as a new length of pipe, was used.

The second coil overhauled was treated the same as the first one, but the third one looked different when the inlet and outlet manifolds were taken down. Instead of the dirty, oily appearance, this coil showed a grayish powder in it, which looked like dry cement. The bottom pipes were filled to a depth of about ½ in., and in taking down the bottom manifold, several quarts dropped out.

So, instead of turning the steam in first, as usual, the air was used, and the air drove out a cloud of gray dust that settled on everything. A burlap sack was tied over the outlet of the next stand, but the dust was so fine that it went out through the sack; however, quite a lot was caught, which was coarse and somewhat resembled sand.

After the dry dust was blown out, steam was turned in, but no oil was found. The condensate came out almost clear water, with just a little grayness showing. Air was turned in right after the steam to dry the moisture.

Air was used first on all the remaining coils and the dust blown out dry. Using the steam first would wet the dust and a great deal of it was not removed.

There was a lot of argument as to the cause of the gray dust. Some of the stands contained more than 3 gal., while others appeared to have but little. Upon examination, it was found that the pipe of the condenser was galvanized both inside and outside.

Ammonia will attack the zinc used in galvanizing and loosen it from the iron pipe. Then an action, which may be called chemical action, is set up which eats on the iron pipe, and which also greatly harms the ammonia. On closer examination, it was found that the pipe was eaten thin in places and small leaks like pin holes had begun to develop.

Coils which showed the presence of oil, together with the gray dust, showed the greatest signs of the eating action. Some of the pipes were sawed in two and the side that had been done showed more wear than the rest of the same pipe. This showed that after the zinc had been loosened from the pipe by the ammonia, it lay along the bottom, and the chemical action was greatest where the most zinc lay. And oil mixed in with it showed that it increased the action.

Just why ammonia and zinc will cause damage to iron pipe and to the ammonia, and why the action is greater when oil is present, I have not been able to learn; but that it is true, I know.

After this condenser had been completely overhauled and cleaned from one end to the other, small pin hole leaks were found very often. In taking out the defective lengths of pipe, the gray dust was noticed again. It was then decided to go over the condensers carefully and whenever a coil containing a leaking pipe was found, the inlet and the outlet headers were to be taken down, and the coil blown out with air. The gray substance was always found, even in those coils that had been blown out four weeks before.

Small metal tags were made, the date of blowing out the coil was stamped on, and the tags were fastened to the coil. Some of the coils were blown out three times in less than four months, and the gray substance was still there to some extent.

How long this action will continue is uncertain; but I believe that as soon as such a condition is known to exist, the installation of a new condenser will save money.

After opening up any part of the ammonia system in a refrigerating plant, the air allowed to enter must be withdrawn before the ammonia is turned in.

This is often neglected, for it seems like a big waste to use one of the ammonia compressors to pump out a coil, and it is hard on rod packing and often considerable ammonia is discharged to the atmosphere with the air, owing to the leaking valves. If there is a small compressor for pump-out work, the pumping out of the air is an easy matter.

In a plant having compound condensing engines, it is simply a matter of operating a valve or two and a vacuum is pulled on the coil that is to be freed of air.

On the condenser, with which this article deals, a pump out header was connected to the inlet manifold of each coil (each coil being provided with a ½-in. valve). This pump out header was connected to the suction side of the ammonia compressors, and the ammonia was pumped out of the coils through this. On this pump out header were also valves for purging noncondensable gases from the condenser.

A ½-in. line was extended from one of the purge valves down and connected into the suction of a dry vacuum pump.

When a coil was ready for the air to be withdrawn, the valves were opened so as to have the vacuum pump pull on the coil. This additional air entering the steam condensing system through the ½-in. line did not affect the regular vacuum at all. The coil was left lined up in this way for about half an hour and immediately on shutting off from the vacuum system the ammonia was turned in. This is the best, most simple and economical way of removing air that I have ever tried.

The cement like substance from the ammonia condensers caused trouble throughout the entire plant.

Often in attempting to shut off some part of the system, it would be found that the valves would not hold. Other valves would be shut so as to pump out the ammonia both sides of the leaking valve, and the bonnet would be removed. Instead of the soft metal valve disc being damaged, it would be found that the cement like substance would be in spots on both the disc and seat, and so prevent the valve being closed tight.

Nearly every valve in the plant was looked into and all needed cleaning. And expansion valves would become clogged tight and have to be removed to punch the stuff out. Even liquid lines on the direct expansion system would be found entirely solid, extending 20 to 40 ft. from a dead end.

The Size of Boiler Feed Pumps

FOUR SIMPLE FORMULAS FOR FINDING THE SIZE OF PUMP REQUIRED. BY E. L. GERE

THE following formulas are based on 30 lb. of water per horsepower per hour, with 20 per cent added for a margin of safety.

Representing the rated horsepower by P, we have at once $30 \times 1.2 \times P$ for the water required in pounds per hour. The volume of water required in cubic inches per minute will then be:

$$\frac{1728 \times 30 \times 1.2 \times P}{62\frac{1}{2} \times 60} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Let d = diameter of cylinder and L = stroke, both in inches. The volume in cubic inches discharged per stroke for a duplex pump will then be $2 \times 0.7854\ d^2 \times L$. The volume in cubic inches discharged per stroke, for a pump with a single cylinder, will be $0.7854\ d^2 \times L$. Good practice requires that a pump be run continuously at a speed not much more than 30 strokes per minute. Using that value, the volume in cubic inches per minute discharged per minute for the duplex pump is:

$30 \times 2 \times 0.7854\ d^2 \times L$ ..... (2)

The volume in cubic inches per minute for the single cylinder pump is:

$30 \times 0.7854\ d^2 \times L$ ..... (3)

Expressions (1) and (2) are equal to the same thing so we place them equal to each other, giving—

$$\frac{1728 \times 30 \times 1.2 \times P}{62\frac{1}{2} \times 60} = 30 \times 2 \times 0.7854 d^2 \times L$$

for the duplex pump. Placing (1) and (3) equal to each other we have, for the single cylinder pump:

$$\frac{1728 \times 30 \times 1.2 \times P}{62\frac{1}{2} \times 60} = 30 \times 0.7854\ d^2 \times L.$$

Solving these equations for d, and reducing, gives for the duplex pump $d^2 L = 0.35\ P$ (Formula 1), and for the single cylinder pump $d^2 L = 0.7\ P$ (Formula 2).

The following example will illustrate the method of using these formulas:

Example: Required the size of single cylinder boiler feed pump to supply a boiler rated at 200 hp.

Solution: Assume the stroke to be 10 in. We then have from Formula 2:

$10\ d^2 = 0.7 \times 200$

$d^2 = 14$

$d = 3.74.$

This shows that too long a stroke was assumed. Take $L = 8$ in., and we have:

$8\ d^2 = 0.7 \times 200$

$d^2 = 17.5$

$d = 4.2$ nearly, say 4 in.

This calculation shows that a single-cylinder pump with a bore of 4 in. and a stroke of 8 in. would do the work.

Some small single-cylinder pumps have a stroke from 3 to 3½ times the bore. Duplex pumps and the larger single-cylinder pumps usually have a stroke from 1⅓ to 2 times the bore. The value of L in Formula 2 may thus be from 3 d to 3⅓ d for a pump to supply a small boiler, although it may be as low as 2 d. In the case of larger steam generating capacity, and for duplex pumps, manufacturers' standards will be found to conform to values for L ranging from 1⅓ d to 2 d.

Denoting this ratio of stroke to bore by R, we have in Formula 1:

$d^2 \times Rd = 0.35\ P$, or

$Rd^3 = 0.35\ P$. Formula 2 reduces in a similar way to $Rd^3 = 0.7\ P$. Transposing and solving for d, Formula 1 becomes:

$$d = \sqrt[3]{\frac{0.35\ P}{R}}$$ (Formula 3), and Formula 2 becomes

$$d = \sqrt[3]{\frac{0.7\ P}{R}}$$ (Formula 4).

The following example will make the method of using Formulas 3 and 4 clear:

Example: Required the size of a duplex pump to supply water to a battery of boilers generating 1000 hp.

Solution: Substituting in Formula 3 and taking the value of R as 1½, we have:

$$d = \sqrt[3]{\frac{0.35 \times 1000}{1\frac{1}{2}}}$$

$= 6.15$, or, say, 6 in.

Stroke $= 6 \times 1\frac{1}{2}$

$= 9$ in.

This shows that a duplex pump with water cylinders of 6-in. bore and 9-in. stroke will do the work required.

(In the Practical Reference Tables of this issue will be found two charts, based upon the formulas given by Mr. Gere, for solving pump problems.—Editor.)

Steam Boiler Accessories

BRIEF DISCUSSION RELATIVE TO PROPER CARE OF SAFETY VALVES AND BLOWOFF CONNECTIONS AND VALVES. BY R. L. HEMINGWAY

SO MUCH has been written on the subject of boilers that it would almost seem as if there were no more to be said, and at the outset it would, perhaps, be as well to admit that this little article is not going to contain anything new about boilers. The object is, stated plainly, to try to bring home to our readers some idea of the terrific energy stored in a boiler under pressure.

Let us take, for instance, a boiler carrying a pressure of, say, 65 lb. per sq. in., and in these days this is an exceedingly low pressure. Possibly the best parallel that can be found will be to compare the energy stored in the water in this boiler to that of gunpowder, and it can be shown quite conclusively that there is as much energy in one cubic foot of water in that boiler as there is in one pound of black gunpowder. Suppose we take a common-sized boiler, 54 in. in diameter by 14 ft. in length. This boiler will probably contain not less than 180 cu. ft. of water, each cubic foot with a potential energy of one pound of gunpowder. Under these circumstances, it behooves every one of us to handle this stored energy with a great deal more respect and consideration than is commonly shown.

Now about the various points that will aid in treating this stored energy with the consideration it merits: Of course, the primary requirement is a boiler capable of withstanding the pressure that is carried upon it, and this should be determined by the inspection of a thoroughly qualified and competent inspector. In the operation of the boiler, the attendant can, by following the recognized rules of operation, greatly minimize danger that may come, either from over pressure or from lack of water. Various fittings and appliances are provided with every boiler and none of these can be regarded as superfluous. Let us take, for instance, the gage glass. This appliance is intended to indicate the true level of the water in the boiler and on an accurate knowledge of this level largely depends the safe operation of the boiler. The fittings of such a water glass are provided with means by which the glass can be blown out, yet it is a fact that this appliance is seldom used in a large number of stationary boiler plants. Almost invariably one will find that the boiler has three try cocks alongside the gage glass, which are placed there for the purpose of checking the accuracy of the water glass. Since necessity has shown that these try cocks should be put on the boiler, does it not naturally follow that they ought to be tried frequently, not only to prove the level of the water in the glass, but also to prove that the cocks themselves are in proper working order? In all probability there is no more neglected appliance on any boiler than these same poor, unoffending try cocks, and yet if the gage glass breaks and another cannot be readily obtained, they are the boiler attendant's sole guide as to the true level of the water in the boiler, on which his safety, and possibly the safety of many others, depends.

The safety valve is another appliance with which every boiler must be equipped. As the name implies, this valve is put on to prevent over-pressure on the boiler, and when the boiler is first installed a safety valve, set to blow at the safe working pressure of the boiler, is always provided, and yet, strange to say, few engineers or boiler attendants seem to think it necessary to test the safety valve, either by running up the steam pressure or by lifting the valve from its seat by the lever that is provided.

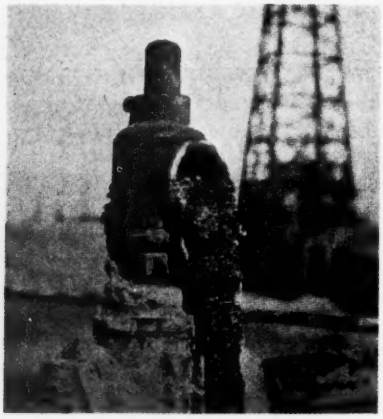


FIG. 1. A MUCH-NEGLECTED POP SAFETY VALVE

In Fig. 1 is shown a safety valve that has apparently grown a beard. The incrustation exuding from the discharge opening of the valve is caused mainly by gypsum salts in the feed water. This causes severe foaming and in consequence it is often difficult to keep water in a boiler, if the safety valve should blow, as the sudden release of pressure causes a violent foaming and consequently the discharge from the safety valve contains a very large percentage of water. A condition of this

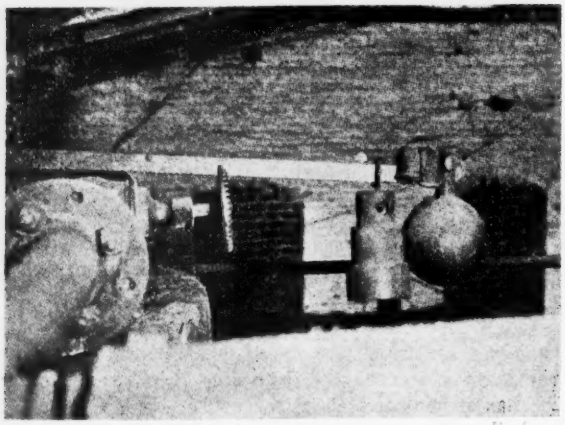


FIG. 2. AN OVER-WEIGHTED LEVER SAFETY VALVE—AN INDEFENSIBLE PRACTICE

kind is very serious, as it threatens to prevent the proper working of the safety valve, because the accumulations are liable to clog up the space between the coils of the spring and so prevent the valve from lifting from its seat when the pressure exceeds that at which the spring should lift.

A procedure in connection with lever safety valves which is to be most severely condemned is that of holding the valve down by the addition of extra weights, as illustrated in Fig. 2. This valve was designed to control a maximum pressure that was to be obtained by hanging the ball weight in the position shown, namely, at the extreme end of the level; but the man in charge of this boiler evidently wanted more pressure, and to obtain this he added the weights. Needless to say, this is an indefensible practice and should not be countenanced in any plant or under any circumstances. Note further the flange joint on the steam pipe, which is only held in place by half the required number of bolts.

The bottom blowoff pipe of a boiler is provided, not only for the purpose of draining the boiler, but also, and probably of more importance, for the purpose of blowing out scale or sediment which otherwise settles in the bottom of the shell and there bakes hard, so forming an inner lining of the boiler, which prevents the heat of the fire being transmitted to the water inside the boiler, and in consequence the shell of the boiler, or in some cases it may be the tubes, become overheated and in many instances being accompanied by serious distortion and sometimes explosion. The moral, therefore, is that the blowoff valve ought to be opened not less than once each day and the boiler allowed to blow for a sufficient period to remove nearly all sediment that may have accumulated at the bottom of the boiler.—California Safety News.

Value of Recording Instruments*

By W. F. Schaphorst

RECORDING instruments are to be had for almost every purpose—for making graphical records of steam pressures, air pressures and other pressures, temperatures, vacuums, speeds, water levels, etc.

There is no question but that these records are of value to the engineer, superintendent and owner. The superintendent can have all of the various gages placed before his eyes over his desk, and thus he can keep in touch with every branch of his plant at all times. If something went wrong the week before at a certain time, he can refer back to the records made at that time and perhaps deduce causes for the error.

I was considerably interested the other day in a record of the amount of power that was transmitted through a belt. A recorder gave the power that was being transmitted through the drive. The belt was slipping, however, and was not carrying as much power as was desired, so the superintendent decided that he would try covering the pulleys with canvas. He did so, and the recorder showed a "bump" at the point where the covering was applied, for from that time on, there was no more slipping and full power was transmitted.

A little rough figuring proved to my own satisfaction that the belt had been slipping about 5 per cent. The covering reduced the slip to 2 per cent, which doubtless is due to the natural creep and cannot be avoided. Hence the pulley covering caused a clear gain of 3 per cent of power without adding to the load on the engine. Besides, it is logical to assume that the belt should last a great deal longer with slip reduced 3 per cent. Friction is the thing that wears out belts, and the principal friction in a belt is that due to slip.

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Babbiting a Generator Bearing

CARELESSNESS on someone's part allowed the cock on the bearing of a 66-kw. generator to remain open and all the oil to run out. The bearing got hot and the babbit melted.

The machinist made two arbors to pour the metal around, one the same diameter for the entire length with a diameter the same as the armature shaft. The other had two collars, B B, Fig. 1, turned on it to fit in the

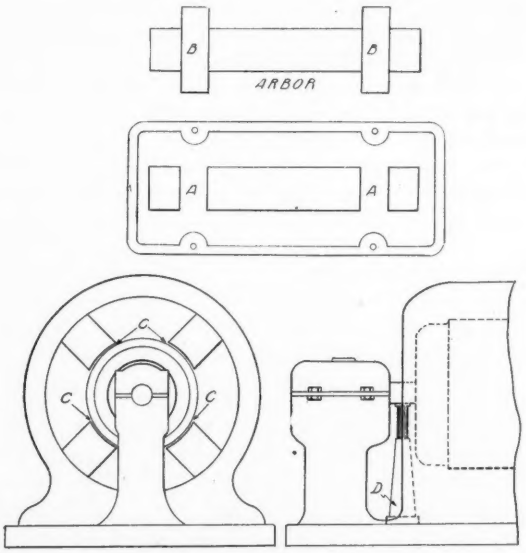


FIG. 1. BEARING CAP AND ARBOR USED IN REBABBITING
FIG. 2. BEARING BABBITED IN PLACE

recesses, A A, in the cap, and formed the runway for the oil rings. The bearing being held to the frame by bolts, it was removed, held in a vise and the old babbit removed by hammer and chisel.

Half-inch holes were drilled at intervals along the length of the bearing a depth of 0.25 in., to anchor the metal.

The arbor was centered by calipers in the box, and the space between the arbor and box at the ends filled with strips of leather, the ends being sealed with a fire-clay putty.

The cap was made ready in like manner, using the arbor shown in Fig. 1. After the metal was poured, the box was scraped by hand to fit the shaft, oil grooves cut, and the bearing then assembled.

When the load was put on the machine, even with the bearing full of oil and the rings turning, the bearing heated and burned out. This was repeated twice. At this time the engineer of another plant was appealed to and he suggested the bearing be poured as shown in Fig. 2.

The old metal having been removed from the bearing, as outlined before, the armature shaft was raised by a small screw jack and blocked in such a position that when feelers were inserted, as shown at C between the fields and armature, the openings were equal. The bottom of the bearing was put in place, then the cap with the spaces, A A, was filled with leather and the ends with putty. The shaft was given a liberal coating of oil and the metal run, using the shaft as an arbor.

When cool, the bearing was taken down, the oil grooves cut and the machine started. It has carried 50 per cent overload and the bearing has given no trouble.

RECEIVER.

Renewing a Pump Liner

FOLLOWING is a description of the means we employed to remove a worn, and reinsert a new liner of 10 by 14 by 15-in. pump. Buying a rough bronze casting of the approximate required dimensions, we placed this in a large engine lathe and bored and finished it to exact size.

The next step was the removal of the old liner, which was accomplished by means of the apparatus shown in Fig. 1, and which as assembled consisted of 1½-in. shaft B carrying member C, a 2 by 4 by 14¾-in. machine

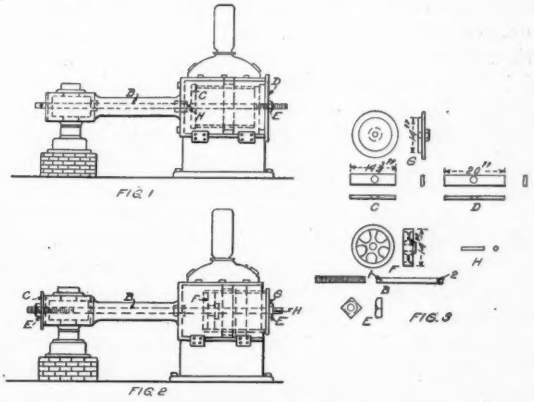


FIG. 1. METHOD EMPLOYED TO REMOVE PUMP LINER
FIG. 2. METHOD EMPLOYED TO INSERT PUMP LINER
FIG. 3. DETAILS OF APPARATUS EMPLOYED

steel strap and D, a 2 by 4 by 24-in. machine steel strap, the former bearing against the liner as indicated and the latter held against the head end of the pump by the tightening up of nut E, fitting on the threaded end of the shaft. Pin H was employed as a backing for member C.

By taking up on nut E, the liner was readily removed.

To draw in the new liner, shaft B, as Fig. 2 shows, was reversed and fitted with member F, an old balance wheel turned down so as to provide a sliding fit with the inside of the liner, and held in place on the shaft by means of a set screw. With this in place we mounted on the end of shaft G, an old face plate turned down so as to provide a flange for bearing against the liner, and secured to the shaft by pin H and B at 2, after which, with the gig and liner in position, C was mounted on the shaft and held in place by nut E. Drawing up on this nut forced the liner into position.

C. R. Williams.

An Apparent Inconsistency in License Laws

Engineers' license examinations everywhere are, of course, primarily intended to determine the applicant's ability to operate a steam boiler with safety to himself and the community at large. But in many cities where license laws are in force, the examinations also include a test of the applicant's knowledge regarding electric and hydraulic elevators. An applicant may run up a brilliant score on the steam boiler end of the examination, only to fail dismally on the elevator end of it, and in such cases he is compelled to continue trying until he equalizes both ends. Still, when he gets his license he is protected from competition with incompetents only in the working of boilers, since the laws usually are not made to cover the everyday care and maintenance of elevators. In the common logic of things, this is not exactly as it should be.

The inconsistency prevailing in this regard was forcibly illustrated recently in the case of a 10-passenger electric elevator running from the basement to the top floor of a club building. The manager of the place, whose own appreciation of the maintenance requirements of any sort of an engineering installation is a quite negligible quantity, had picked up a lad whose chief recommendation was that he had served as a man-of-all-work or porter extraordinary in a hotel or restaurant, and had turned him loose on the establishment in the capacity of maintenance man. What this party did to that elevator during the five or six weeks he was permitted to maim and maltreat it was certainly a-plenty. When the builders of the machine were finally called upon to put it in running order, their workmen found a good solid day's toil ahead of them. They found the finger contacts of the main operating switches burned and blackened and spitting fire every time the machine was started; the commutation brushes of the motor worn down to the holders and the commutation itself burned and roughened and shooting sparks roundabout like a pin-wheel in a pyrotechnic display; the cable ends loose and in danger of short-circuiting the operating switches at every turn of the drum; the brake and safety apparatus inoperative; the ring-oiled motor bearings stuffed full of tallow, and the outfit in general covered with an ample coating of grime and grease.

The most serious aspect of this alleged maintenance man's handling of the job was his blind monkeying with the vital parts of the mechanism whenever the elevator operator registered a complaint about the running of the car. One afternoon the boy reported that he couldn't keep from sliding on the down trip. It developed later on that the maintenance man had been tampering with the brake and had gotten it out of order. Still, it was apparent that he had not associated the inoperative condition of the brake with the sliding of the car; however, since it devolved on him to cure the trouble, he evidently concluded to make a stab at the controlling mechanism in the blind hope that some good might result. The controlling apparatus consists mainly of a tiller rope running over sheave-pulleys at top and bottom of the shaft, with an adjustable counterweight to neutralize the effect of gravity. This counterweight seemed to offer a solution of the difficulty. So, taking a firm grip on his trusty monkeywrench, the lad proceeded to loosen up the set screw and shove the weight in on the lever as far as it would go. The result was that when the elevator boy stopped at any landing below the topmost one, he had to hold the operating lever in the neutral position in order to keep the car standing. If he let go, the lever would promptly swing around to the running position, and the car would instantly bound upward.

This continued from 4 o'clock in the afternoon until 10 o'clock in the evening, when the engineer of the steam plant a block away was sent for to correct the trouble. Every patron of the establishment who rode on the elevator during this interval unconsciously took just about an even chance of being killed or crippled while stepping through the doorway at any landing below the top floor, for his safety depended solely on the sense of responsibility of the bell boys who were detailed indiscriminately to run the car.

A. J. Dixon.

Is the Indicator at Fault?

In the Nov. 15 issue is a letter by Charles J. Mason bearing the above caption. I was well pleased with Mr. Mason's analysis of diagrams in the article which appeared in the July 15 issue, and also read with considerable interest E. C. D.'s article of Oct. 15. I have taken diagrams from engines doing less than 25 hp. and also diagrams from engines doing over 3000 hp., and have argued over the cards until the moon had set and the kerosene had burned out.

It was my fortune to have worked at one time in a 20,000-hp. plant, all in reciprocating units. The engines were regularly indicated about once a year and then they were rarely properly adjusted.

My assistant called my attention one day to a couple of amateurs who were taking cards from a pair of cross compound Corliss engines.

I had previously taken cards from the same pair and had used my own instrument, which was a serious offense. The indicating was done on the night shift, when all was still except a fierce pound in number 2 engine.

I found the exhaust on head-end of the low-pressure, with absolutely no compression, so remedied the defect. Knowing that the engines were in very fair condition so far as valve setting was concerned, I did not propose to allow the amateurs to spoil conditions; but I was only an operating engineer, while the indicator brigade had the sanction of the M. M. and C. E.

After several cards had been taken the indicator brigade retired for lunch, leaving their fieldpiece with the enemy.

My assistant and I immediately took several "pictures." We tied the indicator string to the rocker arm and got a few from both ends, then we went still further and got a motion for number 1 from number 2.

We could easily defy any expert to give a correct diagnosis of the trouble with those engines. At about 2:30 o'clock the brigade re-appeared ready for another hour or two of hard work. I begged the pardon of the brigade master and told him that I had taken the liberty to snatch a few cards while the snatching was good.

He looked at me a few seconds, then said: "We don't like to have our instruments handled by inexperienced men. I trust that you have not harmed them, but please don't do it again."

I promised not to take a chance again of ruining their apparatus and hardly blamed the young man, as I had only had a few years' experience with indicators, while this was his first season. The load was extremely fluctuating, from friction to 125 per cent in a few seconds.

Some of the cards showed ¾ cutoff on the head end and only ⅜ on the crank end of number 1.

"Mr. Thumb, I guess we'll have to adjust the governor rods on number 1, if there is no serious objection," spoke the brigade master.

"Sir, I shall raise very serious objections to any adjustments being made by a semi-professional on engines that I operate," I retorted.

The senior master mechanic was appealed to and he came to the plant and asked my reason for refusing the freedom of the plant to the "indicator experts."

I told him that only one indicator was being used on a cylinder and that the load changed between cards so that the cutoffs could not be adjusted unless the governor was held in one position while the cards were being taken. He agreed with me and we blocked the governor on the next hard pull so that two complete cards were taken. The cutoffs were so uniform that only a difference of 4 lb. was shown by the planimeter in the mean effective pressure.

After the M. M. had gone I asked the expert to tell me what made the indicator take such funny cards for me, and I showed him the freak cards I had obtained.

He said that it was because my experience was so limited that I didn't know how to take a card properly.

I said: "You are mistaken, Mr. Doolittle; those are trick cards, taken to mystify the inexperienced."

Brothers, do not take trick cards to mystify the ignorant and inexperienced. It does not pay. It may act as a boomerang, as it did in my case.

A few years after this indicator affair, having seen a position advertised that looked good and sounded better, I took the train and paid one good dollar and twenty cents for a ride to the city where the job was advertised. I went to the street and number mentioned and was taken with the surroundings. "If I can only land this job, I'll be a stationary cobble hereafter," I thought.

I went into the office and the first man I saw was old friend Doolittle. That wasn't his name, any more than Tom Thumb is mine, but it fitted him O. K. I put out my hand and stretched a smile with, "Good afternoon, Mr. Doolittle. No doubt you remember Thumb, of the Washen and Moburn Steel Works."

"Oh, yes, to be sure. I often think of those tricky indicator cards you took, Mr. Thumb, and do you know that I wouldn't have a man work for me that did tricky work like that? No, sir, I would be afraid he would be doing other tricks."

Don't take tricky cards and then laugh at the other fellow. It cost me, I feel sure, a good job.

TOM THUMB.

Valves From Pipe Fittings

WHILE WORKING as a hoisting engineer, and needing an oil supply tank for filtered oil, I used an empty oil barrel, and piped the oil to run by gravity to the air compressors. My plant equipment was rather limited; nearly everything made from scrap, even the machinery was second or third hand. The whole thing with the owners seemed to be gotten through the contracts with

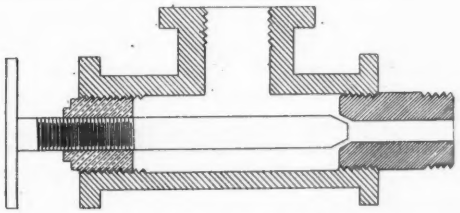


FIG. 1. ANGLE VALVE MADE FROM PIPE FITTINGS

the least expenditure for equipment and supplies. Naturally, they had quite a scrap pile, and from this I made a number of valves, turning up the plugs for seats in the lathe.

The sketches are sectional and easily understood. Any handy mechanic can make all the small valves he wants for use in places where not much pressure is used

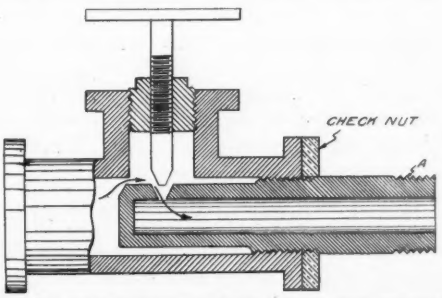


FIG. 2. GLOBE VALVE MADE IN AN EMERGENCY

except that of a gravity weight of a few pounds, such as an oil supply. In making the globe valve, the plug piece, A, in Fig. 2, is screwed up tight, and a check nut to lock it; then the seat is drilled for the valve stem.

C. H. W.

Engine Lubrication Troubles

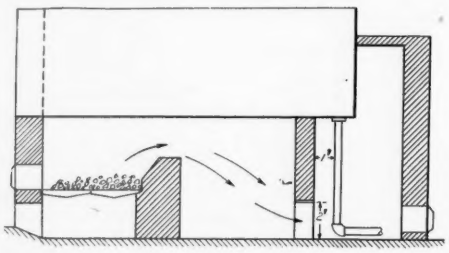
SOME TIME AGO I asked the readers of Power Plant Engineering for advice regarding troublesome lubrication of the cylinder and valves of our 18 by 42-in. Corliss engine. Several remedies were suggested, some of which I adopted with more or less success.

The real cause of my trouble, however, I discovered since then. Running out of cylinder oil, I was forced to get some from a local plant and I noticed, as soon as I had some of this in the cylinder, that not only had my troubles disappeared but I was enabled to run on less than half the amount I ordinarily used.

Of course, I at once discontinued the use of the old oil and I now find it possible to operate on a trifle more than 1/5 of the quantity formerly required. To anyone desiring to know the name of the brand of this oil I will gladly give the information. P. H. WAYNE.

Baffle Arch Prevents Smoke

THE INSTALLATION of brick arches as described by Mr. Anthony on page 923 of Dec. 1, 1917, issue, is a very good idea. About 5 yr. ago I took charge of a plant where they had trouble on account of smoke; in fact, the engineer whose place I took was let out on account of being in court twice for smoking. When I took charge of the place, I went into the boiler room and studied the conditions and came to the conclusion that by building an arch behind the bridge wall, I could prevent smoke. I not only prevented smoke, but there was also a saving in coal. Care must be taken that the arch is not built so low as to shut off the draft. My arch comes within 2 ft. of the floor. I have no more trouble and the job cost $40 for two boilers, and it is certainly worth the price. From blowoff pipe to this



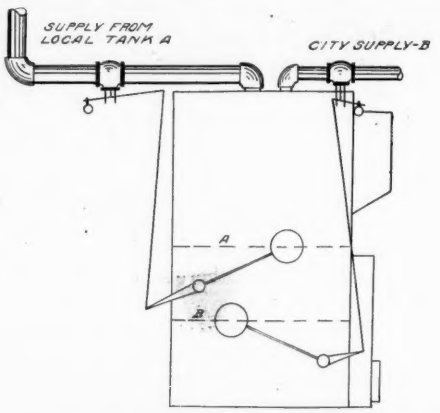
LOCATION OF BAFFLE ARCH FOR PREVENTING SMOKE

arch is 1 ft. The gases coming over the bridge wall following the boiler, strike the arch, drop down, then pass through the boiler. WM. FUNK.

Insuring Supply of Water to Heater

IN A PLANT with which the writer is acquainted, the main supply of feed water was taken from a storage tank which also held water for industrial purposes. The water for the boilers was led to the feed-water heater, whence it was pumped hot to the boilers, the admission of the water to the heater being controlled by means of a balanced regulating valve and float arrangement which held a water level line at A, as noted on attached sketch.

Several times when the demand of the water for industrial purposes was heavy, it was found that there was a deficiency of water for the boilers, and whenever this occurred it was necessary to admit cold water quickly from a city service main into the heater, during which time hand regulation was relied upon. This auxiliary or supplementary water supply was later made to operate automatically by installing another float and regulating valve connection in the heater, as shown. This supplementary float was set so that it closed its regulating valve at the water level, B. Therefore, as long as the supply of water from the tanks was sufficient to supply the demands on the heater the water level was maintained at point A, and the regulating valve on the city supply was kept tight shut because of the position of its float at B. If the supply of water from the tanks failed, however, the water level in the heater would naturally fall until it went below point B, when the float on the city supply line dropped and admitted sufficient water to maintain a level at B. All this time the valve on the line from the tank was wide open because the float operating it was at such a low level, hence as soon as any water was available from the tank it flowed into the heater until the city supply was



AUTOMATIC ARRANGEMENT FOR SUPPLYING WATER TO HEATER DURING EMERGENCY

shut off and the water level maintained at A. In other words, the city supply was brought into action only at such times as the local tank supply failed, and all this was automatic in action. M. A. SALLER.

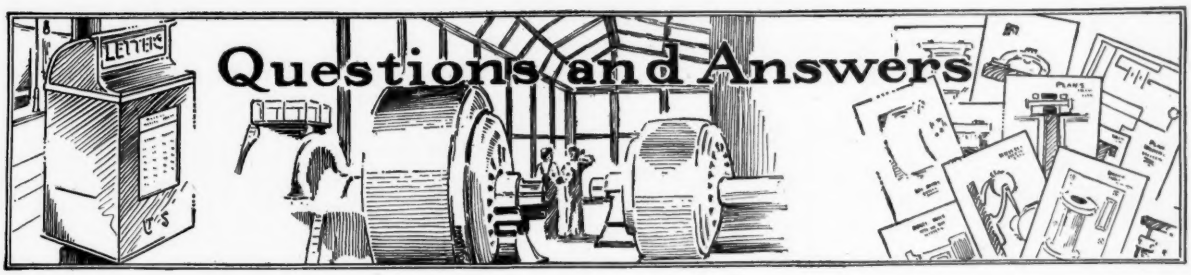
Saving Babbit Metal

IN THESE days of food conservation, fuel conservation and conservation of everything else, it is the duty of the engineer to use supplies as sparingly as possible.

Recently, having a large bearing to reline and not having a melting pot large enough to hold the required supply of lining metal, I decided to leave some of the old metal in. The babbit was originally about ¾ in. thick, so I chipped out about ⅜ in. of it and drilled some radial holes in the inner surface of the old babbit to anchor the new, and proceeded to rebabbit in the usual manner. So far it has proved to be a success.

THE CHIEF.

AMONG THE NUMEROUS TESTS and investigations conducted by the National Bureau of Standards during the past year, have been researches on magnetic system for testing steels to ascertain the quality for tool making, ball bearings, etc., improved methods of light measurement, standard practice codes for electric and gas service, standards for street lighting service, and the safeguarding of underground structures from damage caused by stray electric currents.



Refrigerating Plant Operation Questions

I AM OPERATING a 25-ton Vilter refrigerating machine, the compressor being 10 by 12 in. and belt driven, running at a speed of 70 r.p.m. The brine tank is 5½ by 8 by 24 ft. and is heavily insulated.

To what degree of temperature should the brine be cooled?

What should I do if the ammonia appears to back up in the receiver? Open the expansion valves? Or does it not matter if the receiver is very nearly full? If I close the expansion valves so my low-pressure is about 22 lb., the receiver fills up; but if I open the expansion valves ½ or ¾ of a turn, the receiver will run about 3 in. of the ammonia into the gage glass. Which is right?

I have two expansion valves; can I run with one or is it best to use both?

Is it customary or advisable to use a clutch on a belt driven compressor when you have full sized bypasses? If so, why? E. S. R.

A. I cannot tell how many degrees the brine in the tank should be lowered in any given time, for you do not state what you are using this brine for. Here are some of the things that must first be known:

How many pounds or gallons of brine are circulated per hour? What is the temperature of the rooms through which the brine is circulated? How is the brine used, in coils, over curtains or by the spray system? How many degrees difference is there between the outgoing and incoming brine? What is the density? What means of refrigerating the brine in the tank is used; that is, are there coils in the tank or is a shell or double pipe cooler used? Facts at least covering all the above questions must be known.

The liquid receiver should at all times contain sufficient liquid ammonia to insure sealing of the outlet. The Vilter receiver, being of the upright type, should contain at least liquid to the height of half the glass. More than this is not necessary, but is not harmful in any way. Three inches in the glass is not enough, as gas will pass directly from the condenser to the evaporating coils by way of the expansion valves. Regulate expansion valves so that liquid level is constant at half the glass full. If this cannot be done and hold the temperatures, more ammonia in the system is the most likely remedy.

When two expansion valves are installed to feed two coils in a brine or ice tank, it is best and proper to use both valves as the distribution of ammonia is more even than if but one valve were used. It also helps to keep proper circulation.

A clutch is seldom used on a belt driven compressor. A clutch must be thrown in tight at once or the slippage will soon wear it out. And the sudden gripping of a clutch will jerk the belt. Avoid the clutch-type of drive and use the rheostat. A. G. SOLOMON.

Operation of Electric Generators

I WOULD LIKE to know the proper way to start up a direct-current generator and cut it in on the line. Also, how would you cut a second machine in parallel with the first one?

Kindly explain how this is done with alternating-current machines. F. J. V.

A. We presume that what you desire to know is how to parallel direct-current and alternating-current generators with machines already in operation. In the case of a direct-current generator, it is, of course, first necessary to bring the machine up to proper speed, and then by means of a shunt field rheostat, have the machine build up its terminal voltage equal to that of the bus bars. The machine may then be thrown on to the bus bars, the procedure, of course, depending to a great extent upon the scheme of wiring employed. Generally, however, it is first necessary to put in the circuit breaker and then the main knife switches; this includes the equalizer switch. After you have thrown the incoming machine on to the bus bars, it is necessary to readjust the rheostats with the various machines so as propertly to divide the load.

In the case of alternating-current generators, bring the machine up to speed, then throw in the field switch so as properly to energize the field of the generator, and by means of the field rheostat, as in the case of a direct-current machine, bring the voltage up to that corresponding to the voltage of the bus bars. We cannot, however, in this instance, throw in the machine directly on the bus bars, as is done in the case of a direct-current generator. Characteristics of the alternating current machine require that the incoming machine be synchronized with the machines already in operation; that is, the rise and fall of the voltage of the incoming machine must correspond to the rise and fall of the voltage of the bus bars. This is accomplished either by means of lamps arranged and provided for the purpose, or better, by means of an instrument called a "synchroscope." When you find that the incoming machine is in step with the bus bars, and that the voltage of this machine is the same as that of the bus bars, the main switch may be thrown in. It will, of course, also, with the alternating-current machine, be necessary to divide the load properly amongst the various generators.

When desiring to cut out any machine operating in parallel with others, first reduce the load on the outgoing unit by cutting resistance into the field circuit and

when this has been done trip the circuit breaker. This procedure must be followed especially in the case of alternating current generators. O. H. H.

Thermal Properties of Ash

PLEASE FURNISH ME with what you consider a good analysis of ash. Is there a practical method whereby the unburned coal and coke removed from boiler furnaces can be separated from the ash for burning over?

S. R. B.

A. We presume what you wish is an idea of how ash will respectively run as compared to fuel.

Tests show all kinds of variation. A soft coal from Illinois region showed 13.3 per cent refuse in the ash pit; combustible in the refuse, 31 per cent of the refuse, which amounted to 4.3 per cent of the coal used.

Pittsburgh coal showed 8.1 per cent refuse; 26 per cent combustible in the refuse, which was 2.1 per cent of the coal.

Arkansas coal showed a wide variation. One test showed 10.3 per cent refuse, 30 per cent combustible, which was 3.1 per cent of the coal. Another test showed 40 per cent refuse, having 83 per cent combustible, which was 33.2 per cent of the coal.

Tests on anthracite have shown from 10 per cent to 23.7 per cent refuse, of which 18.7 to 11.9 per cent was combustible, which was 2.2 to 2.7 per cent of the coal.

The amount of combustible to be found in the ash varies greatly with the kind of coal handled, the space between grate bars, size of fuel and other conditions. Ash in coal is running high this year, and probably 12 to 18 per cent is not an abnormal amount; but with careful handling it ought to be possible to hold combustible down to 20 per cent of the ash, which would be not much over 2 per cent of the coal.

As to the composition of ash itself, there is little data. Tests made by Bryan on ash from Illinois coal, which showed from 7.5 to 16.25 per cent ash in the coal, gave silicon dioxide running from 22.8 to 60 per cent; iron oxide running from 3 to 52 per cent; aluminum oxide running from 3.2 to 31 per cent; calcium oxide, running from 1.9 to 34 per cent; and magnesium oxide running from 0 to 2 per cent.

So far as we know, no method has been found of reclaiming the combustible which is in the ash. Any process would probably be prohibited by the expense as compared with buying of new coal. The practical thing is to see that the grates and the method of handling the fire are fitted to the fuel, so that as small a per cent as possible is carried through into the ash, and then watch the work of the fireman to make sure that he lives up to the method adopted. A. L. R.

Criticism of Ammonia Compressor Cards

THE MACHINE from which the cards shown by G. P. H. on page 982 of the Dec. 15 issue have been taken, I presume, has a piston valve mechanically operated to control the ammonia to the cylinder. If that is the case, the intake valve must be closing too late (the piston having traveled on the return stroke from ⅔ to 1 in. before the valve closes). The discharge valve opens too soon. If there is any way by means of which this valve can be kept closed until the piston has traveled 9 or 9½ in. and without keeping it open after the piston has reached the end of its stroke, G. P. H. will find a considerable reduction of power resulting.

If these valves may be adjusted to open and close to suit the notion of the operator, I would advise that he retard the opening of the discharge valve until a hump appears in the discharge line of the indicator diagram; then advance it until the hump disappears. Also advance the intake valve until it closes when piston is on center, being sure that the discharge valve closes when the piston has completed the stroke and that the intake valve does not open until the piston has moved 2 or 3 in.

L. L. RINGLE.

Criticism of Indicator Cards

PLEASE REFER to card criticism desired by J. W. P. in Dec. 1 issue, page 945.

In analyzing an indicator card, it is always of assistance to know the type of engine; that is, whether it is equipped with independent steam and exhaust valves, for without such information the person criticizing—with a view to improving conditions—may be in error.

If the admission line could be maintained at the required pressure to point of cutoff, it would compensate for the reduction in area caused by reducing pressure at the point of exhaust opening. On the card with load of 150 amp., there appears to be insufficient lead at head-end, but only to a slight extent. The revolutions per minute are high and may account for the rounded corners of the card where the admission and expansion lines join at point of cutoff. This may be caused by the throttle not being fully open, and it may be caused by wiredrawing due to insufficient port areas. Furthermore, the exhaust opening takes place rather early in the stroke, resulting in relatively high pressures. While the total area of the card would be somewhat reduced, it would be advisable, in my opinion, to reduce the pressure of the exhaust, carrying it to a point further along in the stroke, provided this can be accomplished without increasing the back pressure.

On the 200 amp. cards, neither the point of cutoff nor the point of exhaust opening are well defined.

I would suggest that J. W. P. follow the practice of locomotive men by attaching his indicator to the steam chest, and previous to taking cards take a card of the steam chest pressure. If the pressure in the chest is maintained to satisfy the demands of the cylinder at the revolutions given, then the indicator will draw a straight line on the card.

If, however, the restrictions such as valves, elbows, etc., in the line to the chest cause a loss in pressure, there will be a loop in the line from point of admission to that of cutoff.

It is a good plan to check the compression, or retarding pressure, against the steam pressure beginning at the point of exhaust opening.

On both cards, the two pressures equalize at a point near the completion of the stroke; but it is possible that there is sufficient pressure of compression remaining to cushion the reciprocating parts. At the point of equalization, the pressure is 15 lb., which comes on the piston suddenly as a full retarding pressure.

If the pressure at point of exhaust were reduced, as previously described, the compression would occur earlier on the piston and be of less pressure.

In general, the cards appear fair; but it would be interesting to have J. W. P. give reasons for the relatively high back pressure on the top pair of cards.

W. O. MOODY.

More Power with Two Eccentrics

ON PAGE 972 of the Dec. 15 issue, Tom Thumb states that in a certain rolling mill the chief engineer claims his single eccentric Corliss engine to be cutting off at about 7/8 stroke.

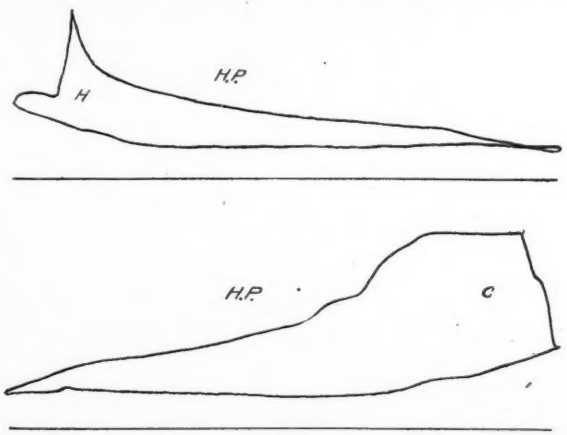
I do not understand how a single eccentric Corliss engine has a 7/8 cutoff when authorities claim that such an engine has a limit of about 1/2 cutoff or perhaps at most a trifle more. I would like this question discussed by some of our worthy brothers in such a way as to show how a single-eccentric Corliss engine can cut off as late as 7/8 stroke and still operate satisfactorily.

N. EWING.

Peculiar Indicator Cards From Tandem Compound Engine

SHOWN HEREWITH are some indicator cards taken from a 13 and 22 by 16-in. tandem compound noncondensing engine equipped with a flywheel governor and operating at a speed of 242 r.p.m. under a steam pressure of 140 lb. gage.

These cards were submitted by H. M., who desires that they be criticized. Will not some of the readers of Power Plant Engineering submit their opinions as to the probable trouble with the valve setting and its proper remedy?

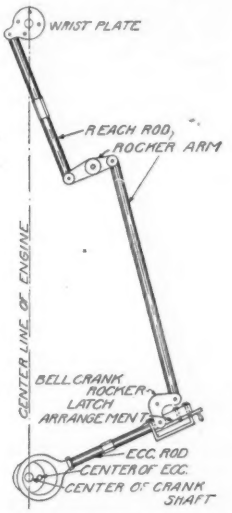


CARDS TAKEN FROM LOW AND HIGH-PRESSURE SIDES OF TANDEM COMPOUND ENGINE

Relocating Wristplate Marks

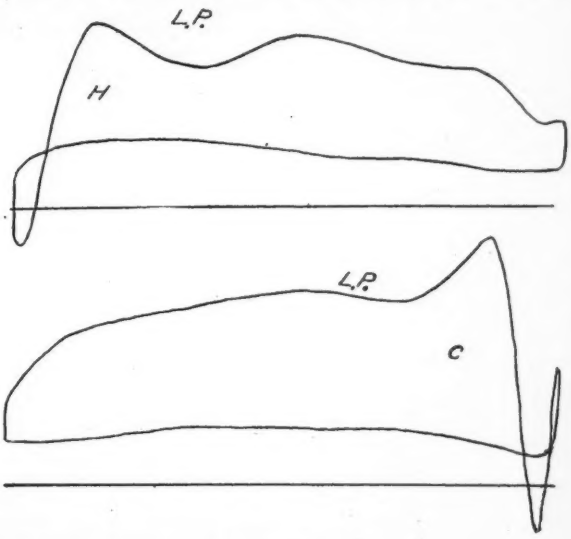
IT WAS with much interest and benefit that I read the comments of the Chief, F. E. Bacon, Frank Wells, E. M. and Receiver in the Nov. 15 issue to my inquiry on page 829 of the Oct. 15 issue, relative to the relocation of wristplate marks. But their methods, I see, are all for horizontal engines, while the one I had reference to was one of the vertical type with mechanism arranged as shown in the accompanying illustration.

I realize I ought have made a statement to the effect that it was a vertical engine, but failed to do so.



HOW MAY E. B. P. RELOCATE THE WRISTPLATE MARKS ON AN ENGINE HAVING A GEAR OF THIS TYPE?

I wish that, if not asking too much of the readers of Power Plant Engineering, they would tell me how to relocate the wristplate marks on a machine of this type.



The valve gear is so arranged that it may be operated from the ground floor. E. B. P.

BRICK made from coal ashes, suitable to substitute for fireclay brick, building brick, etc., is possible, so it is claimed by a new process which has recently been developed by a brick company of Scranton, Pa. Tests have shown that these bricks placed in service and subjected to 3000 deg. F. (1650 deg. C.) gave three times the service that the common firebrick gave. The fusion point is from 2600 to 3250 deg. F. (1427 to 1788 deg. C.), depending on character of binder used; crushing strength, 130 lb. and over to the square inch, with a 22.5 per cent porosity.—Chicago Journal.

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The H. C. of L.

If you interpret this as the high cost of living, it is a problem that we have with us every day, and with rapidly increasing difficulty. No question but it is to remain a problem, for with war expenditures of the government, increasing taxes, shortage of labor and materials and rising wages and prices, our balance of values will be greatly disturbed.

There is one consoling thought. The government, through control of prices and distribution, is endeavoring to ease the burden as much as may be done and to insure that no source of supply of the necessities of life is left unproductive, also that waste of necessities is reduced to a minimum.

Spite of governmental effort, unless the co-operation of the whole people is secured through widespread knowledge of the need for such co-operation, and arousing of the spirit to help willingly in making a success of the government's program, the results will be far short of a complete success.

And in the tax bill passed by the last Congress was embodied a section which will have the effect of hampering co-operation by seriously injuring and to a considerable extent destroying the very agent that is most useful in spreading knowledge of why and how to co-operate—the periodical press.

This section, embodying the pernicious zone idea, will, if carried out, result in a high cost of learning that will react on the efficiency of all industry. The rates set, for the immediate present, are sufficient to wipe out most of the periodicals, and are made progressively increasing, not with an idea of raising a fund for war taxes, but as an exploitation of the ideas of a few men in political life, and as a punishment for periodicals that have dared to criticize the actions of political leaders.

The zone system of rates for second class postage will force publishers to penalize those readers living at a distance from publication centers.

This is a result, the very opposite of what the government should desire. Campaigns to raise funds for Red Cross, Y. M. C. A. and other auxiliary agencies which aid in caring for our troops are easily carried on in large towns and cities by organized personal canvass; but the press is the only means of reaching those in outlying territory and in smaller communities, a population fully as large as that which can be reached by personal touch.

No publisher has protested against any equitable war tax that may be imposed, on either income or profits; but the zone system and the proposed rates will wipe out at a stroke, by an increase of costs greater than all the profits from all sources, the agency that has given freely of time and space to further every government purpose, and that has been no inconsiderable factor in the success of the Liberty Loans.

The only alternative to destruction of the periodicals, both those of general interest and the business papers in special fields, is a zone system of subscription rates that will bear heavily on all readers except those living within a few hundred miles of the city where a publication is issued.

This means real high cost of learning for the majority of the readers. Books are useful for general reading

and for fundamental principles; but for learning the latest methods of business and industry, particularly with the rapid changes that present conditions will enforce, only the frequent visit of the business or technical magazine is adequate. To destroy these publications, or to cripple them by restricting to a small local circulation, will be a step that President Wilson himself, when governor of New Jersey, condemned. He said in regard to a proposed increase in rates on advertising sections, much less than that in the bill recently passed:

"This proposed new postal rate would be a direct tax, and a very serious one, upon the formation and expression of opinion . . ."

"To make such a change now, whatever its intentions in the minds of those who propose it, would be to attack and embarrass the free processes of opinion. Surely sober second thought will prevent such a serious blunder."

The conditions are more serious now than then. It is more important than ever before that all citizens be fully informed about the progress of political and industrial life of the entire nation.

Every reader is vitally concerned in the matter, for the present law means the destruction of nearly every periodical that he reads, the depreciation and an almost prohibitive cost for those that manage to survive.

Many senators and members of the House were and are opposed to the law. The way to prevent this disaster is to convince every congressman that the country is opposed to this monstrous injustice and the iniquitous zone system. This must be done by letting your congressman know how you feel about it, and getting others to do the same. The remedy is in the hands of the millions of readers. You are one. Write the senators from your state and the member of Congress from your district at once.

Records

Increasing costs of fuels, oils, supplies, labor, and in fact practically all items entering into the operation of power plants, have reached unprecedented levels, causing much concern to engineers, particularly those in charge of the smaller plants. As in normal times, however, the operator who has maintained an itemized record of plant performance and cost of operation will with much satisfaction to himself and his employer be able to determine with readiness the exact increases which have occurred and thereby be in a position to reduce or perhaps even eliminate many items heretofore deemed indispensable. On the other hand, the engineer who through neglect or otherwise has failed to install, not an elaborate, but a thoroughly practical accounting system, will be much at sea relative to the performance of the equipment under his charge, and while certain of his inability to produce at as low a figure as six months or one year ago, will have no means by which to determine accurately and locate many leaks which, if eradicated, might reduce his cost of operation materially.

Much of the success enjoyed by large power stations, and especially those operated by public utility corporations, may be attributed to carefully maintained system of records employed. If, therefore, the operators of such plants find it of advantage to maintain records which embody not only daily, monthly and yearly operating data, but also serve as permanent statistics, there hardly appears room for argument against the employment of such systems in plants of the smaller capacities.

Due, however, to varying details of construction and operation, no standard record form can be prepared for use in any and all plants, and as a consequence, many engineers who desire to install such a system are at a loss to the proper procedure, both as to the number and form of record best adapted to their particular plant. Consistent, therefore, with the general policy of Power Plant Engineering, and the desire of its editors to be of the greatest possible assistance to its readers, we would be pleased to cooperate with any engineer desiring to install an accounting system suitable to the needs and requirements of his plant. If any of our readers wish to take advantage of this service, we would suggest that they inform us to that effect and when doing so submit the fullest possible particulars regarding their plants, including a list of all equipment, together with the ratings of the individual apparatus and the service to which each such piece of apparatus is put.

What Would You Do?

If called upon to design and construct, within the shortest possible time, a refrigerating and ice-making plant of a capacity such as to meet the daily requirements of 40,000 persons? This is what government engineers were up against in the construction of the Rockford Cantonment. Would your design and specifications differ materially from those employed in this installation?

Outdoor steam carrying lines must be well insulated to reduce condensation losses to a minimum. What kind of insulation would you employ for 8-in. lines?

How much, do you estimate, might the efficiency of your plant be increased by the installation of steam-flow meters?

Could you reduce your operating costs by substituting oil for coal? It might pay you well to investigate by applying the methods of calculation employed by G. S. Blankenhorn on pages 85 and 86, to your plant.

Smokeless combustion of coal is desirable both from the standpoint of economy and civic pride. How can you, in your plant, aid to reduce this nuisance to a minimum?

What type of arrester is today conceded to provide the most effective insurance against lightning damage? How is it constructed and what is its principle of operation?

Why should not piping galvanized on the inside be used for ammonia service?

Can you readily determine by means of any formula you have ever seen, the size of pump required to feed a boiler of a specified rating?

Have you read this issue so carefully that you can answer these questions?

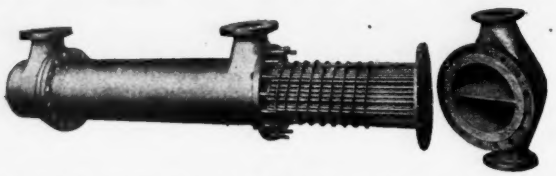
Index for 1917

The Index for Volume XXI of Power Plant Engineering is now prepared and will be sent free to subscribers upon request.

Multiwhirl Cooler for Lubricating and Quenching Oils

REALIZING the demand for an efficient device for the cooling of lubricating oils for turbine bearings and reduction gears and that used in quenching tanks, the Griscom-Russell Co., 90 West St., New York City, has recently placed upon the market the Multiwhirl Cooler shown in the accompanying illustration.

Essentially this cooler consists of a cast-iron casing or shell containing a nest of smooth bore copper tubes expanded into steel tube plates, one of which is of floating head construction, allowing for expansion and contraction of the tubes without strain on the expanded joints. Oil passing through the shell is brought into



GRISCOM-RUSSELL MULTIWHIRL OIL COOLER WITH TUBES PARTLY WITHDRAWN

intimate contact with the comparatively cool surface of the tubes by means of a patented helical baffle, the construction of which is such as to insure a long, smooth oil path with minimum pressure drop. Cooling is accomplished by the circulation of water through the tubes.

The entire nest of tubes is removable for the purpose of inspection without breaking oil connections. The whirling motion of the oil passing through the shell tends to keep the surfaces clean, but should it become necessary to clean the tubes, this may be readily done by withdrawing the nest of tubes.

News Notes

AT A RECENT MEETING of the Board of Directors, C. P. Coleman was elected president of the Worthington Pump and Machinery Corporation.

RIDGWAY DYNAMO & ENGINE CO., Ridgway, Pa., announces the appointment of the Blake Electric Mfg. Co., No. 1 Rowes Wharf, Boston, Mass., as its sales representative for the New England States.

THE VILLAGE of Chardon, Ohio, on Jan. 2, voted an issue of $25,000 of bonds which will be used in connection with $50,000 issued last year for new equipment for the lighting plant and pumping station owned by the village. E. C. Thompson, chief engineer, is in charge of the plant.

MANY FIRMS are finding their personnel heavily depleted by men entering national service. Even though they may be engaged in such important work as helping to overcome the fuel shortage by the installation of coal saving devices, the call for men must be met.

Combustion Engineering Corporation has had to give up a considerable number, among whom are: C. L. Bachman, former manager of the Chicago office, now lieutenant of engineers; O. de Lorenzi, of the testing department, now second lieutenant of engineers; Geo. M. Bechtel, of the estimating department, who has enlisted in Base Hospital Unit No. 3; Walter Erlenkotter, of the testing corps, now second lieutenant of engineers, and Marcus Morley, of the same department, first lieutenant of engineers; Hugh Campbell, formerly in the designing department, is now at Camp Upton; Robert Weber, of the same department, is in the Naval Reserve of the Third District; Herbert Ahearn is in the New York Naval Militia, Fifth Battalion; Murray Harris is sergeant at Camp Upton; P. Nelson Hunt is in the United States Aviation Corps; Raymond Zimbis, of the Flying Corps at Mineola, L. I., and J. M. Hunter, of the Royal Flying Corps.

THE GOULDS MFG. CO., Seneca Falls, N. Y., manufacturer of pumps, has put into effect a bonus system whereby all hourly, piece work and salaried employes rated at $40 a week or under, will receive quarterly, a bonus of 10 per cent on their total salary for the previous 3 mo. This bonus is contingent upon a stipulated amount of time being put in at actual work during the year, and is aimed to encourage full time work.

FRANK W. HALL has been appointed commercial manager of the Sprague Electric Works of General Electric Co. With the exception of a short period, Mr. Hall has been connected with the Sprague Works continuously for 22 yr. in various engineering and sales capacies, and for the 3 yr. prior to his present appointment occupied the position of sales manager. D. C. Durland, former executive head of the Sprague Electric Works, has resigned to accept the presidency of the Mitchell Motors Co., Inc.

THE ARMY AND NAVY STAFF departments continue to demand men of engineering experience, especially in industrial lines. At present, the outlook is that this demand will continue throughout the period of war.

In calling attention to this, the United States Public Service Reserve, Washington, D. C. (where records of men willing to serve when called will be kept on file), points out that a man of engineering experience has a rare combination of opportunities open to him, which are not open to the average patriotic American, as follows:

I. To serve the country in his most effective capacity.

II. To keep in touch with his own profession, with the result that this patriotic service will not have caused him to become rusty by the time peace returns.

III. To become a commissioned officer and receive much better pay than the average man who has wholly subordinated personal interests and now works for the national good.

IV. To perform his service usually without leaving the United States.

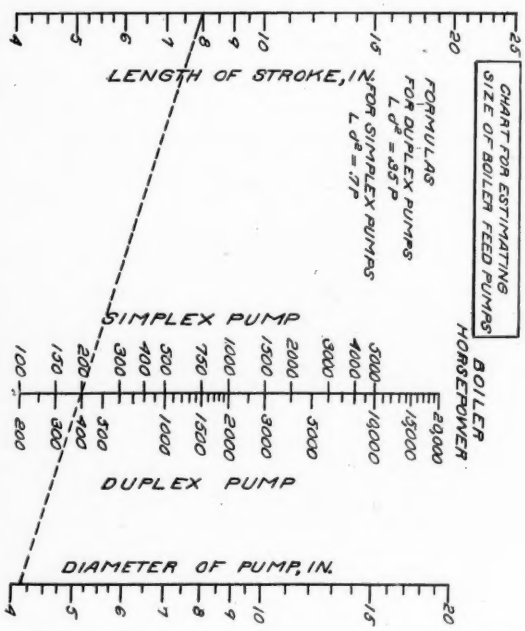
Book Reviews

AMERICAN STATIONARY ENGINEERING, by W. E. Crane, Third Edition, 1917, 311 text pages, 5 by 7½ in., illustrated; New York. Price, $2.

This book is a plain talk on everyday work about engines, boilers and their accessories. It is not intended

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

POWER PLANT ENGINEERING


LENGTH OF STROKE, IN.
CHART FOR ESTIMATING SIZE OF BOILER FEED PUMPS
FORMULAS FOR DUPLEX PUMPS L d² = .35 P
FOR SIMPLEX PUMPS L d² = .7P
SIMPLEX PUMP
DUPLEX PUMP
BOILER HORSEPOWER
DIAMETER OF PUMP, IN.

POWER PLANT ENGINEERING

Specific Gravity, Fusing Points and Conductivity of Metals

Metal	Specific Gravity	Weight per Cubic Ft.	Melting Point Deg. F.	Elect. Cond. Silver = 100
Aluminum	2.67	166.5	1175	63.
Antimony	2.76	421.6	1160	3.59
Bismuth	9.80	611.7	485	1.40
Brass	8.40	523.8	1650	------
Bronze	8.85	552.	1692	------
Cadmium	8.60	536.9	576	24.38
Cobalt	8.55	533.1	6000	16.93
Copper	8.85	552.	1940	97.61
Gold, pure	19.26	1201.	1935	76.61
Iridium	22.38	1396.	4280	13.52
Iron, Cast-Pig	7.21	450.	2200	------
Iron, Wrought-bars	7.70	480.	2900	------
Lead	11.38	709.7	620	8.42
Magnesium	1.74	108.7	1200	39.44
Manganese	8.	499.	6000	15.75
Mercury	13.58	846.	39	1.75
Nickel	8.8	548.7	2600	12.89
Platinum	21.5	1347.	3110	14.43
Silver	10.5	655.	1800	100.
Steel	7.85	489.	2600	12.
Tin	7.35	458.	449	14.39
Tungsten	17.3	1078.7	5252	14.
Zinc	7.	436.5	786	29.57

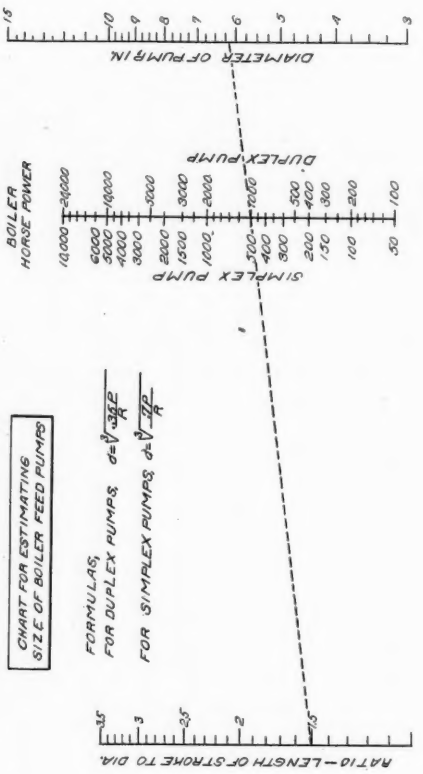
POWER PLANT ENGINEERING

SQUARE FEET OF HEATING SURFACE REQUIRED TO HEAT 1000 POUNDS OF WATER PER HOUR.
$U = 350$.

Initial Temperature of Feed Water, t_0.	Vacuum Heaters between Engine and Condenser.										Atmospheric Heaters.						Initial Temperature of Feed Water, t_0.
	24″ Vacuum. Temperature 141° F.						25″ Vacuum. $t_s = 134°$ F.				Atmospheric Pressure. Temp. 212° F.						
	Final Temperature of Feed Water.																
	105	110	115	120	125	130	110	115	120	125	192	196	200	204	208	210	
40	2.93	3.36	3.36	4.50	5.22	6.29	3.93	4.65	5.58	7.01	6.01	6.65	7.58	8.73	10.72	12.74	40
50	2.64	3.29	3.57	4.15	4.93	6.01	3.65	4.36	5.28	6.65	5.94	6.58	7.44	8.58	10.51	12.51	50
60	2.29	2.93	3.22	3.86	4.58	5.65	3.29	4.01	4.93	6.29	5.79	6.44	7.15	8.36	10.38	12.30	60
70	1.93	2.50	2.86	3.43	4.22	5.29	3.07	3.58	4.57	5.86	5.58	6.22	7.01	8.23	10.15	12.15	70
80	1.50	2.07	2.43	3.01	3.72	4.86	2.36	3.07	4.01	5.36	5.37	6.01	6.87	8.00	9.94	11.85	80
											5.15	5.79	6.57	7.80	9.80	11.79	90
	26″ Vac. $t_s = 125°$.				27″ Vac. $t_s = 114°$.			28″ Vac. $t_s = 100°$.			4 93	5.51	6.36	7.51	9.52	11.50	100
	Final Temperature of the Feed Water.										4.79	5.46	6.22	7.37	9.37	11.37	105
											4.65	5.28	6.15	7.22	9.23	11.15	110
	105	110	115	120	90	100	105	70	80	90	4.50	5.15	5.93	7.08	9.08	11.07	115
40	4.43	4.93	6.07	8.18	3.22	4.72	6.01	1.93	3.14	5.08	4.36	4.93	5.79	6.93	8.95	10.94	120
50	3.92	4.57	5.72	7.73	2.79	4.36	5.58	1.43	2.57	4.57	4.15	4.79	5.64	6.79	8.80	10.80	125
60	3.36	4.15	5.36	7.51	2.29	3.86	5.08	.78	1.93	3.93	3.86	4.65	5.44	6.57	8.65	10.58	130
70	2.86	3.65	4.79	6.86	1.71	3.22	4.50	.....	1.14	3.14							
80	2.29	3.07	4.28	6.28	.86	2.21	3.79	.....	.....	1.93							

—GEORGE F. GEBHARDT.

HIGH TEMPERATURES JUDGED BY COLORS (Kent)		
Colors	Centigrade	Fahrenheit
1 Red, visible in dark	400	752
2 Red, visible in twilight	474	885
3 Red, visible in daylight	525	975
4 Red, visible in sunlight	561	1070
5 Dark Red	700	1292
6 Cherry Red	900	1652
7 Bright cherry-red	1000	1832
8 Orange-red	1100	2012
9 Orange-yellow	1200	2192
10 Yellow-white	1300	2372
11 White welding-heat	1400	2552
12 Brilliant white	1500	2732
13 Dazzling white (bluish white)	1600	2912



DEGREES OF DIFFERENCE BETWEEN STEAM TEMPERATURE AND ACTUAL AVERAGE TEMPERATURE OF FEED WATER.

Initial Temperature of Water, t_0.	Vacuum Heaters between Engine and Condenser.										Atmospheric Heaters.						Initial Temperature of Water, t_0.
	24″ Vacuum. Temperature 141° F.						25″ Vacuum. Temp. 134° F.				Atmospheric Pressure. Temp. 212° F.						
	Final Temperature of Water.						Final Temperature of Water.				Final Temperature of Water.						
	105	110	115	120	125	130	110	115	120	125	192	196	200	204	208	210	
40	62.9	59.3	55.3	50.9	46.2	40.6	50.1	45.7	40.6	34.6	70.6	65.7	60.1	53.5	44.8	38.2	40
50	59.2	55.6	51.9	47.7	43.1	37.8	46.7	42.4	37.7	32.1	67.9	63.1	57.6	51.2	42.8	36.4	50
60	55.5	52.1	48.4	44.4	40.1	35.1	43.2	39.3	34.7	29.4	65.1	60.4	55.2	48.9	40.7	34.7	60
70	51.6	48.2	44.8	41.1	36.9	32.1	39.7	35.9	31.2	26.6	62.2	57.7	52.6	46.6	38.7	32.9	70
80	47.6	44.2	41.0	37.5	33.5	29.2	35.9	32.4	28.4	23.8	59.4	54.9	50.0	44.2	36.6	31.0	80
											56.4	52.3	47.4	41.8	34.4	29.1	90
											53.1	49.3	44.7	39.3	32.4	27.3	100
											51.9	47.9	43.4	38.2	31.4	26.4	105
											50.3	46.4	42.1	36.9	30.2	25.5	110
											48.8	45.0	40.6	35.7	29.2	24.5	115
											47.2	43.5	39.2	34.4	28.0	23.5	120
											45.6	41.9	37.8	33.1	26.9	22.5	125
											43.9	40.3	36.4	31.7	25.8	21.5	130

Initial Temperature of Water, t_0.	26″ Vac Temp. 125° F				27″ Vac. Temp. 114°.			28″ Vac. Temp. 100°		
	Final Temp. of Water.				Final Temp. of Water.			Final Temp. of Water.		
	105	110	115	120	90	100	105	70	80	90
40	42.0	40.4	35.0	28.3	44.4	36.0	30.8	43.2	36.3	27.9
50	39.9	37.3	32.3	25.9	40.8	32.8	28.0	39.1	32.7	24.8
60	38.2	34.1	29.4	23.4	36.9	29.6	25.1	34.7	28.8	21.6
70	34.3	30.8	26.9	20.7	33.0	26.2	22.1	.....	24.7	18.1
80	30.8	27.3	23.3	18.1	28.7	22.5	18.7	.....	.....	14.4

—GEORGE F. GEBHARDT.

to be scientific or mathematical, but formulas are put in simple form so that anybody understanding plain arithmetic can readily understand any of them. A large number of questions are presented upon subjects treated but direct answers are not given in all cases, as it is the intention of the author that these answers should be worked out by the reader with the help of the text.

In the section on "The Boiler Room," the author deals with such subjects as water testing, safety valves, firing methods and tools, boiler feeding and feed pumps, boiler cleaning, boiler settings, strength of boilers, boiler explosions, steam and water piping, masonry and chimneys. Other chapters are devoted to the Engine Room in general; Corliss Engines; Engine Valves; Air Pumps and Condensers; Tools for the Engine Room; Belting; Oils; Cleaning; Notes, Rules and Tables; Boiler Economy; Indicating and Diagrams.

While essentially elementary in its character, this book contains a great amount of information which can be put into practical use in any power plant and will be found of value by students and those beginning their career as power-plant engineers.

EXPERIMENTAL GENERAL SCIENCE, by Willard Nelson Clute, 303 pages, 4¾ by 7¼ in., 96 illustrations; Philadelphia, 1917. Price, $1.25.

Written primarily as a text book for students of the high school or academy grade, this book is, nevertheless, interesting reading to anybody having a taste for the sciences. It deals in necessarily brief manner with subjects under the general classifications of astronomy, physics, chemistry, physical geography, living things, evolution, bacteria and physiology. Throughout the book, fundamental laws and relations are presented upon which more advanced study may be based; but the book is particularly valuable for giving to the reader a general knowledge of the sciences and their relations to each other and one's everyday living.

THE PUBLISHERS of Lefax are now including a number of sheets on military subjects as a part of their loose-leaf data sheet service. The sheets so far issued consist of digests of government publications on such subjects as the cleaning and care of rifles, semaphore and other forms of signaling, drill regulations, range tables, description and operation of rifles, principles and modern developments of trench warfare and methods of estimating distances. The sheets are of uniform size, punched to fit the standard loose-leaf pocketbook and are indexed on the same plan as the Lefax data sheets covering the various branches of engineering and general subjects. They are published by Lefax, Inc., Sheridan Building, Philadelphia.

Catalog Notes

MULTI-STAGE CENTRIFUGAL PUMPS made by The Goulds Mfg. Co., Seneca Falls, N. Y., are illustrated in that company's Bulletin No. 120, which also discusses their characteristics, installation and operation.

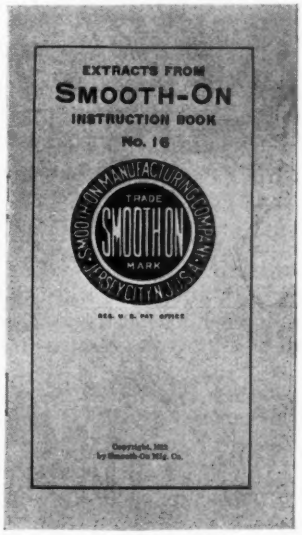
BULLETINS have been received from Wayne Oil Tank & Pump Co., Fort Wayne, Ind., on the following subjects: Long distance gasoline or oil pump, storage systems for oils and gasoline, filter for gasoline, storage system for rubber cement, galvanized tanks for storage of gasoline and other liquids underground, heavy metal storage tanks, pump head with meter, discharge nozzles and accessories, filling devices, fill boxes and transfer pumps, power pumps for lubricating crude and paint oils, gasoline and naphtha.

CHAPMAN TYPE ball bearings for transmission are described and illustrated in Catalog No. 3, recently issued by The Transmission Ball Bearing Co., Inc., Buffalo, N. Y.

THE FILES ENGINEERING CO., Inc., Providence, R. I., has just issued a booklet containing brief instructions regarding design, construction and operation of the Files hand stoker.

THE VILLAGE BEAUTIFUL for Mill Operatives is the title of a pamphlet from Connecticut Mills Co., Danielson, Conn., explaining and illustrating the housing ideals of that company.

A 16-PAGE CIRCULAR, Extracts from Smooth-On Instruction Book No. 16, which is a new edition of this book, is being sent out by Smooth-On Mfg. Co., Jersey City, N. J. The circular contains the standard sizes



of Smooth-On coated corrugated gaskets for flanged pipes from 2 in. up to 26 in. The company will be pleased to send this publication to anyone requesting it.

LINK-BELT CO., of Chicago, is sending out a very attractive 12-sheet calendar, one sheet for each month, with pages 16 by 25 in., printed in three colors. Copy of this will be sent, on request, to any responsible person. The request should be addressed to Link-Belt Co., 39th St. and Stewart Ave., Chicago.

THE SECOND of a series of catalogs of industrial motors has just been distributed by the Westinghouse Electric and Manufacturing Co., of East Pittsburgh, Pa. This is known as Catalog 30 and covers the company's complete line of direct-current motors and generators for industrial service.

After several pages giving general information regarding the ordering, classification and selection of direct-current motors, there follows complete description, rating and dimensions for Type SK commutating-pole motors, various modifications of Type SK elevator motors, reversing planer motor equipment, Type CD motors, headstock equipment for woodworking plants, Type SK and CD motor generators and arc welding equipment. Much new information is given, especially on such subjects as arc welding, headstock equipment, motion picture service and battery charging service.

The new catalog is identical in size and will fit the binder for the company's line of catalogs covering supply apparatus and small motors.

SIL-O-CEL insulating brick, powder and cement designed for use as a backing for firebrick in furnace walls, boiler settings and other equipment, is the subject of circulars from Kieselguhr Co. of America.

Booklets relating to the same subject contain reprints, entitled, respectively, High Temperature Insulation and Report on Heat Insulating Materials.

Trade Notes

NAGLE CORLISS ENGINE WORKS, of Erie, Pa., have opened an office in the Bourse Building, at Philadelphia, to give direct representation in that section.

RUSSELL T. GRAY, recently secretary of the Shuman Advertising Co., has opened an office in the First National Bank Building, Chicago, and offers advertising service in the technical field which involves knowledge of engineering sales problems.

THE HOPPES MFG. CO., Springfield, O., announces the recent appointment of W. R. Jennison as its Southeastern representative. He will handle the entire line of Hoppes products in that district, with headquarters at 407 Bisbee Bldg., Jacksonville, Fla.

AFTER 9 YEARS' EXISTENCE as a department of the Chicago Pneumatic Tool Co., the motor truck interests were taken over on Jan. 1 by a new organization, the Little Giant Truck Company.

The concern will handle a full line of trucks from 1 to 5 tons, equipped with the Duntley gas generator, permitting the use of kerosene and distillate. The new company is owned and controlled by the Chicago Pneumatic Tool Co., and the officers for both companies are the same. Headquarters will remain at 1615 Michigan Ave., Chicago, as heretofore.

THE ECONOMY FUSE & MFG. CO., of Chicago, has purchased the entire fuse business of the Detroit Fuse & Mfg. Co., makers of Arkless Enclosed Fuses. This covers all merchandise and materials, machinery, designs, patents and unfilled orders. The manufacture of Arkless fuses will be continued in Chicago by the Economy Fuse & Mfg. Co., under the label service of the Underwriters' Laboratories, Inc. The manufacture of Economy Renewable Fuses will also be continued. The "Square D" line of enclosed safety switches remains the property of the Detroit Fuse & Mfg. Co., who will continue its production and marketing.

POWER PLANT ENGINEERING

Trade-mark, Reg. U. S. Pat. Off.

SEMI-MONTHLY

PUBLISHED THE FIRST AND FIFTEENTH OF EACH MONTH

Subscription price in advance in the United States, Mexico or united possessions, $1.00 a year.

In Canada, subscription price, $1.75 a year.

Foreign Countries, subscription price, $2.50 a year.

Address all letters and make all checks and money orders payable to Technical Publishing Co., 537 S. Dearborn St., Chicago, Ill.

Any advertiser is invited to examine our paid subscription lists and Post Office mailing receipts at any time.

ADVERTISING RATES

Display

Full page, one year, each insertion, $66.00.

Half page, one year, each insertion, $38.50.

Quarter page, one year, each insertion, $22.00.

Eighth page, one year, each insertion, $13.25.

Front cover, $175.00 per issue.

Other specified positions, regular rate plus 10 to 50 per cent.

Stippled plates used, but no heavy, black and white plates.

Classified Rates

Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 22,300.

Technical Publishing Co.

537 S. Dearborn Street

Chicago

Position Wanted

POSITION WANTED—By engineer experienced with producer gas and oil engines, a.c. and d.c. equipment, pumps, storage batteries, interior wiring and repair work. Technical graduate. References. Address Box 501, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-1-1

POSITION WANTED—By young man as oiler in large central station, with 7 years' experience with Corliss engines up to 400 hp., d.c. generator. I. C. S. graduate on complete Steam Engineering. Age 27. Married. Best of reference. Will go any place. Address Box 493, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-15-1

POSITION WANTED—As helper or oiler in small or large plant. Will come at once. Sober and industrious. Will consider reasonable salary. Address Box 494, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-15-1

POSITION WANTED—By young man as oiler or assistant engineer in or around Chicago, with chance of advancement. Eight years' experince; ready to start work at a week's notice; references. Address Box 492, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-15-1

POSITION WANTED—By steamfitter with 17 years' experience at the trade. Can furnish references as to habits and ability to handle men. I am 33 years old. Married. Address J. H. D., 669 Wunderlick St., Barberton, O. 10-15-5

POSITION WANTED—By practical engineer of 15 years' experience. Am familiar with a.c. and d.c. generators and motors, also refrigerating machinery. Am 38 years old, married and strictly sober. Good references. E. W. Jones, Genl. Del., Metropolis, Ill. 1-15-1

POSITION WANTED—As engineer or oiler in power or ice plant. Have had 15 years' experience. Fred J. Waite, 659 Douglas Ave., Aurora, Ill. 10-15-2

POSITION WANTED—Chief engineer desires change of location. Competent to handle large plant. Experienced with a.c. and d.c. machinery, irrigating machinery, ammonia compressors (practical ice-maker), gas engines and air compressors. Can install and o repairs. Not liable to conscription. Address Box 495, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 10-15-2

POSITION WANTED—As chief engineer. Am familiar with a.c. and d.c. generators and refrigerating and steam heating plants. I desire change. I can furnish good references and have been with present employer about 4 years. Age 35. Single. Address Box 715, Middleton, Conn. 12-1-1

POSITION WANTED—As chief engineer for manufacturing plant by technical graduate. Four years as chief in present plant. Age 30. Married. A1 references. Present salary $1800. R. R. Rogers, 32 Cordova St., St. Augustine, Fla. 1-1-1

POSITION WANTED—As watch engineer in power or ice plant. Ten years' experience. Married and sober. Frank Wells, 210 Pearl St., Jeffersonville, Ind. 1-1-1

Help Wanted

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal.; Washington, D. C. This is an excellent chance for a hustler, who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscriptin Department, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf.

BOILER ROOM FOREMAN WANTED—For 5000 b.hp. plant, Stirling and B. & W. boilers, induced and natural draft, economizers, chain grate stokers. Must be able to handle operation, maintenance and efficiency work and get results, None but thoroughly competent and experienced men need apply. Middle West city of 60,000. State age, experience, etc., fully and present salary. Address Box 503, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-1-2

Wanted

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial or put it to test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio. tf.

WANTED—Agents handling engine and boiler room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Box 381, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—Marine boilers. We will pay cash awards for information that leads to a purchase by us of marine boilers of from 75 hp. to 250 hp. The Pittsburg Boiler & Machine Co., Pittsburg, Kan. tf.

WANTED—Agents who call upon engineers to sell positively the best pump valve on the market Commission basis. Excellent proposition. Address Box 500, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—Good second-hand steam engine indicator outfit, with carrying case. Give description and lowest price in first letter. Address Box 502, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-1-1

WANTED—Agents handling engine and boiler room specialties in every section for our Boiler Girth Seam Protector. Liberal inducements. Give experience and territory covered. Address National Boiler Protector Co., Dayton, Ohio. tf.

WANTED—Desire to purchase a complete set of 1916 copies of Power Plant Engineering (formerly Practical Engineer). State price. Address Box 504, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-15-3

For Sale

FOR SALE—Atlas Engine, ready for prompt shipment and immediate use. Size 22x30, left-hand drive wheel, 12 ft. in diameter, 3-ft. face, shaft 10 in. in diameter with wheel governor. This engine was developing 500 hp. when taken from our plant and is in very good running condition. Will sell for $800. Address The Parker-Young Company, Lisbon, New Hampshire. 1-1-2

FOR SALE—250-volt direct connected units: 75 kw. 3 wire 250-125 volt, with Harrisburgh engine, $1800 each; 60-kw. Allis Chalmers-Watertown, $1200; 50-kw. Allis Chalmers-Chandler Taylor, $1100; 50-kw. G. E., 3 wire 250-125 with Harrisburgh, $1350; 37½-kw. Westinghouse-Skinner, $1100; 30-kw. Sprague-Harrisburgh, $900; 25-kw. G. E.-A. & S., $700. Power Machinery Exchange, Jersey City, N. J. tf.

Patent and Patent Attorneys

PATENTS THAT PROTECT AND PAY—Advice and books free. High references. Best results. Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St. N. W., Washington, D. C. tf.

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact costs. Send for full information. tf.

A. P. CONNOR, Consulting Electrical and Mechanical Engineer, Attorney-at-Law and Solicitor of patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

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Sparks From The Advertising Pages

Where Buyers and Sellers Meet

A Trustworthy Criterion of Value

Both a live wire and one that carries no current look alike. One has the potential energy to run factories, to light many homes, to do the work of hundreds of human hands, while the other is inert, powerless.

Appearances are usually deceiving. This is as true of power plant equipment as of anything else.

In the early days when men brought their goods into a common market to barter what they had for what they needed, they learned to trust the character of the trader rather than the appearance of his merchandise.

Today as then the character of the seller is the safest criterion of the value of the thing for sale. Glossy paint, high polish, or staunch-looking design, often cover a multitude of faults, weakness, cheap materials or poor construction.

The dependable test of quality in power equipment is who makes it, who says it is good, who stands behind it.

The duty of an engineer is to keep his plant running smoothly, economically. His value to his employer is proportionate to his ability to produce results, and he is able to do it only as his equipment generates and delivers efficiently.

It is vital, therefore, that he should buy only such equipment as can be depended upon. He cannot afford to be content with anything short of maximum performance.

How can he be sure of getting such equipment? By dissecting it in advance? That is seldom possible and always impracticable. By experience with it? That is costly and unnecessary,

The answer is: by purchasing advertised, trade-marked equipment, because advertising is the great modern protective agent of the buyer.

In these days of rapid and extensive business operations it is not possible to know personally the character of the men or organizations whose products we buy. But, we can know their character through their advertising,

—provided that their advertising appears in a responsible medium, a publication which is as careful of the kind of advertising it accepts as you are of the kind of persons you admit into your home. Advertising in such a publication must be the honest expression of a responsible seller.

No advertiser is admitted to the pages of POWER PLANT ENGINEERING who does not measure up to the POWER PLANT ENGINEERING standard of character. That is why you can buy the products advertised in it with assurance that they are as represented.